AN ENVIRONMENTAL OVERVIEW OF BIG CREEK, YUKON AS RELATED TO PLACER MINING ACTIVITY

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AN ENVIRONMENTAL OVERVIEW OF BIG CREEK, YUKON AS RELATED TO PLACER MINING ACTIVITY

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Placer Research and Development Committee

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NOTICE: The Authors' observations, recommendations and conclusions are their own, and do not necessarily reflect the views of the government departments involved.

EXECUTIVE SUMMARY

1 INTRODUCTION

This project was undertaken, after review by the Joint Committee on Placer Mining Research and Development, to gather survey level information on water quality and quantity, aquatic resources, terrestrial resources and land use in the Big Creek watershed. The project was designed to provide a basis of reference for the preparation of project proposals for short and long term environmental impact research and monitoring activities. As well, it provided a base level of information for the area that is immediately useable. The integrated approach used may be transferable in varying degrees to other drainages.

2 METHODOLOGY

The initial requirement was to select a project area. A main consideration was to seek areas with problems in stream classification and linkage concerns. Four potential areas were evaluated against eight specific criteria and rated. The mainstem of Big Creek was determined to be the most suitable area. Government agencies each took part in a field program and although working independently co-ordinated field activities to the extent possible.

The parameters investigated included water quality, water quantity, benthic invertebrate populations, sediment characteristics, fish inventory, land use activities, wildlife habitat and outdoor recreation. Methodologies varied from helicopter flyovers to specific water quality, sediment and fish inventory sampling.

3 RESULTS

Water Quality and Quantity

The general water quality at all sample station locations was similar to water quality results reported by Mathers et al (1981) and

Burns (1980). Certain total metals concentrations occasionally exceeded recommended levels for drinking water and/or recommended limits for aquatic life.

Water quality parameters on the mainstem of Big Creek varied spatially with a general trend to increasing concentrations moving downstream from Big Creek Stations 1 to 6. The largest increases in mainstem concentrations occured at Stations 3 and 5, downstream of Mechanic and Seymour Creeks.

Temporal variation was noted in water quality parameters between sampling periods. Most water quality concentrations were higher during August than in July or September.

Suspended solids concentrations in Big Creek never exceeded 50 mg/l at the downstream station. Increased suspended solids concentrations at Stations 5 and 6 on Big Creek were attributable to the effect of placer streams where these concentrations were extremely variable.

Fish Inventory

Chinook Salmon - One mature male chinook salmon was seen at the confluence of Seymour and Big Creeks on August 7, 1984. Chinook fry were captured from Big Creek, Seymour Creek up to it's confluence with Bow Creek and on Bow Creek to 500 metres above the confluence with Seymour Creek. Chinook fry were also found in Stoddart Creek. Marginal rearing habitat was identified on Magman Creek although no chinook fry were captured.

Arctic Grayling - Adult and subadult arctic grayling were found at all sampling sites except in the upper reaches of Stoddart Creek. Grayling fry were collected only from Big Creek near the confluence of Revenue Creek.

Benthic Invertebrates and Sediment Characteristics

Benthic Invertebrates - Benthic invertebrate populations varied temporally and spatially as reflected by taxonomic composition and community index comparisons. This variation could not be

attributed to any particular event. The diversity indices, community indices and taxonomic features reflect natural diverse populations. Any influence of placer activity on the tributary streams of Big Creek could not be detected by the benthic invertebrate data from the mainstem of Big Creek.

Sediment Characteristics - Streambed sediment sampling was carried out in conjunction with water quality and benthic invertebrate sampling. Sediments were analysed for particle size composition and metals content. Particle size composition varied significantly among stations however spatial and temporal differences observed could not be related to specific events. Particle size composition was seen to be most uniform at Station 6 on Big Creek. Sediment metals content varied significantly during the sampling period at various stations. The pattern of variation over time could not be related to a specific event or activity.

Land Use

Land use in the area is related mainly to placer activity, hard rock exploration and associated roads. While the extent of area disturbed appears relatively low, no quantitative assessment has been undertaken, nor have the environmental characteristics of the area been evaluated.

Wildlife and Outdoor Recreation

Due to a lack of time and resources, information was not obtained on these subjects.

4 SUMMARY AND RECOMMENDATIONS

Summary

Four alternative approaches for further research and monitoring have been identified by the study group.

1. There is a general consensus among the government agencies involved that the placer mining potential of the area has to be reviewed. A detailed placer deposit geology investigation would be valuable to

this end. Other terrestrial environmental characteristics such as soil type and slope also need to be examined.

2. Monitoring of water quality and aquatic resources on the mainstem of Big Creek should be continued to provide a longer record and additional detailed sampling in the tributary streams should be conducted to further examine system linkages.
3. Research and monitoring could be conducted which would add to the knowledge base of the area and have indirect policy implications but would primarily focus on developing an understanding of system processes. Included here are ideas related to rehabilitation in streams and changes to stream morphology and substrate as a result of increased sediment loads.
4. The present survey approach with the modifications identified, would be an effective mechanism for obtaining valuable management information in the evaluation of other drainages where placer mining occurs.

Recommendations

There is a need for decisions to be made on the value of undertaking environmental impact research and monitoring before long term programs are implemented.

It is recommended that the perceived placer potential, based on current industry and government knowledge, of the Big Creek area be used to direct further work.

Given there is future development potential, it is recommended that a combination of approaches 1 and 2 be undertaken in the short term. This would address certain specific information gaps and policy issues.

Given there is limited development potential in this area, it is recommended that approach 4 be implemented in other placer drainages. This would involve information collection at the survey level.

An investigation of the placer geology should be completed before long term programs are implemented.

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1 INTRODUCTION

1.1 Background

During 1983, a public review of the proposed placer mining guidelines was conducted by the Yukon Placer Mining Guidelines Public Review Committee. This Public Review Committee subsequently released it's recommendations in a report to the Ministers of the Department of Indian Affairs and Northern Development (DIAND), the Department of Fisheries and Oceans (DFO), and the Department of Environment (DOE). Many of the recommendations identified a need for more information on the economic implications of the proposed guidelines, and the need for better resource information (renewable and non-renewable) for land use (resource use) planning. It was also recommended that government establish a process to ensure that the placer industry and environmental interests have an ongoing role in developing and implementing policy and regulation and that government undertake research in certain areas.

A Joint Committee on Placer Mining Research and Development was formed. Representation included industry and the federal and territorial governments. The purpose was to review and make recommendations on proposed research and data collection projects that respective government agencies were planning. The present study is one of several projects undertaken by the two levels of government in 1984 to develop a better information base and profile of the placer mining industry.

1.1.1 Objectives. Based on the information presently available and the lack of information, the agencies involved agreed that there was a need to approach the study of a selected drainage in a coordinated and integrated manner to obtain the most useful information for the least cost. It was decided to select one area for a preliminary investigation in 1984 so that it could be objectively evaluated for future long term studies of impacts associated with placer mining and with the possibility of proposing effective mitigation measures where needed.

Four potential study areas were evaluated based on criteria specified by an intergovernmental working group. The original study proposal is included as Appendix I of this report. The results of this evaluation identified the mainstem of Big Creek to be the best suited location to fulfill the selection criteria and would achieve the study objectives which are as follows:

a) gather information such as water quality, stream flow, aquatic resources (fish and invertebrates), wildlife data, outdoor recreation potential and land use information that will be of value for environmental assessment and dealing with issues on the particular stream;
b) gather data and obtain results that are transferable, in varying degrees, to other streams;
c) evaluate the potential for establishing a permanent "demonstration stream" or "demonstration drainage" as a basis for long term research and monitoring.

1.2 Overview of Big Creek Area

1.2.1 Big Creek Watershed Description. The study area is centered on the mainstem of Big Creek approximately 50 km northwest of Carmacks (Figure 1) and 37 km (Figure 2) from its confluence with the Yukon River. Figure 2 identifies the study area in greater detail.

The source of Big Creek is in the vicinity of Prospector Mountain (elevation 1975 m) and Apex Mountain from where it flows east then north to its confluence with the Yukon River (elevation 480m) just downstream of Minto as illustrated in Figure 1. The Big Creek drainage has a total area of about 1750 km^2 of which three major tributaries, Dark Creek, Stoddart Creek, and Seymour Creek make up 340 km^2, 89 km^2 and 259 km^2 respectively. Big Creek has a steep gradient in the upper reaches. The middle and lower reaches have a much lower gradient where the stream assumes a meandering pattern. The majority of the drainage area is contained within the Dawson Range Ecoregion with only the lower portion extending into the Pelly River Ecoregion as defined and described by Oswald and Senyk (1977).

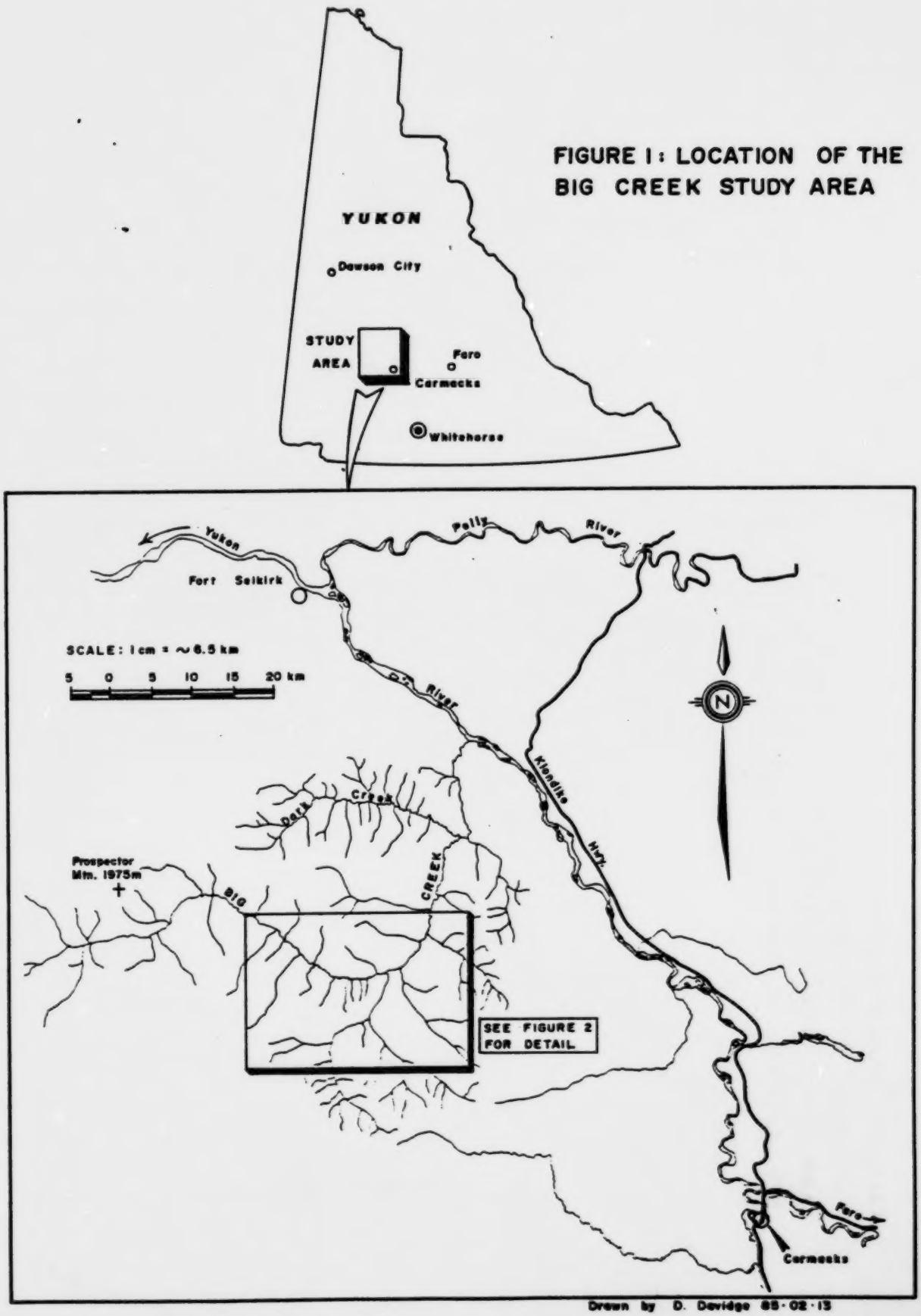


FIGURE 1: LOCATION OF THE BIG CREEK STUDY AREA

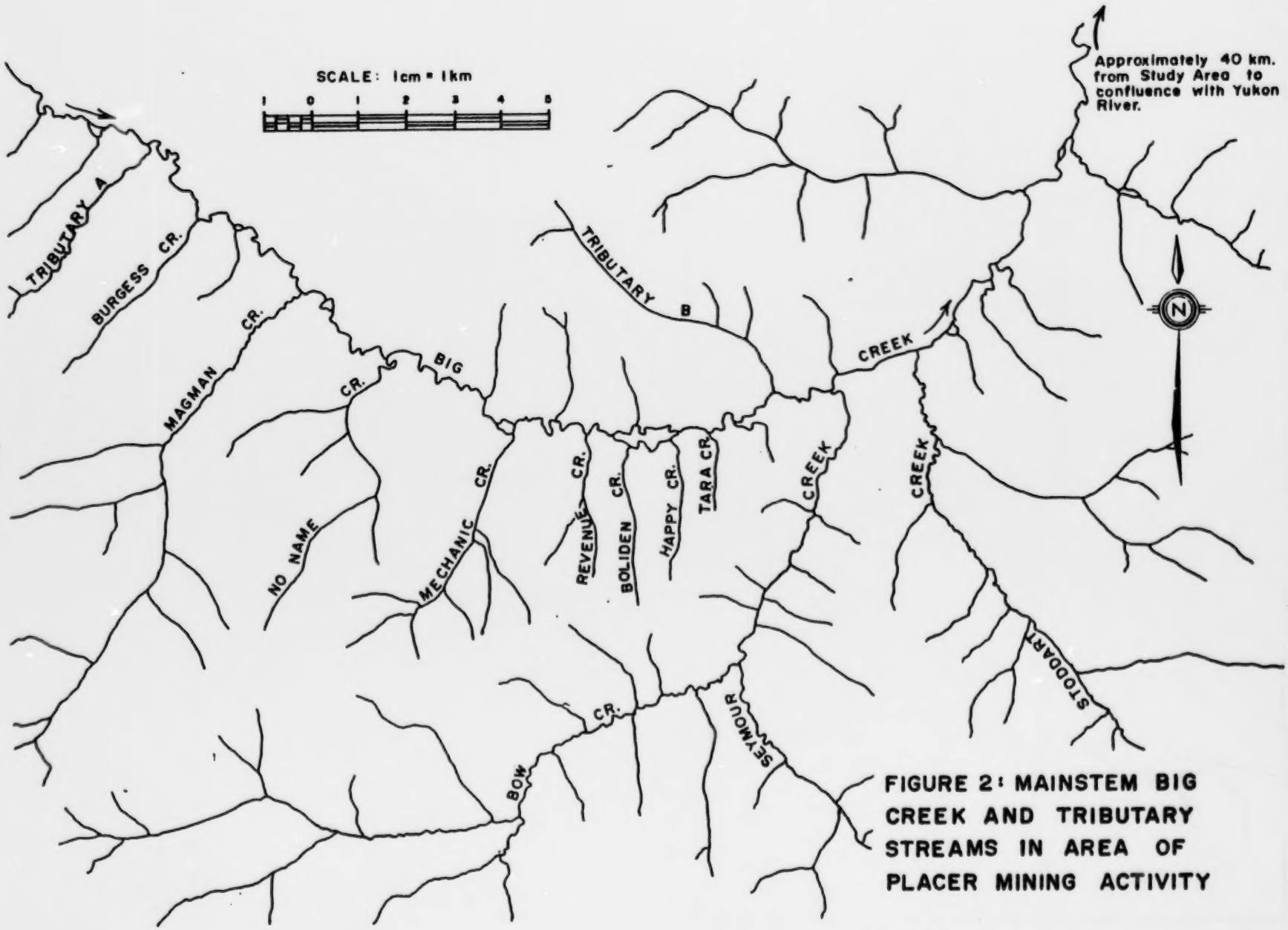


FIGURE 2: MAINSTEM BIG CREEK AND TRIBUTARY STREAMS IN AREA OF PLACER MINING ACTIVITY

Drawn by D. Davidge 85-02-13

1.2.2 Climate. Limited climatic data exists for the region however, the climate is generally described as continental and cold with a mean annual temperature of approximately -7°C and average precipitation of about 300 mm (Oswald and Senyk, 1977). Precipitation is variable, depending on proximity, elevation and position of mountains. July, August or September are frequently the wettest months. Table 1 presents historical climatic data for Carmacks and Fort Selkirk (Oswald and Senyk, 1977).

TABLE 1 SELECTED CLIMATIC DATA FOR TWO STATIONS NEAR BIG CREEK, Y.T.

STATION	ELEVATION (m)	MEAN ANNUAL TEMPERATURE (°C)				PRECIPITATION (mm)	
		Ann.	May-Sept.	Jan.	July	Annual	June-August
Carmacks	521	-5	10	-34	14	247	107
Ft. Selkirk	437	-5	11	-30	15	276	113

1.2.3 Geology. Oswald and Senyk (1977) have summarized the work of Templemann-Kluit on the bedrock geology of the Aishihik area which is common with part of the Dawson Range Ecoregion within which most of the Big Creek drainage occurs. Large bodies of metamorphic rocks, primarily quartzite, biotite schist, amphibolite and quartz mica schist dominate but are intruded with igneous rocks, such as quartz diorite and granodiorite. Volcanic rocks such as andesite, basalt, tuff and breccias, are prevalent in the southern parts. Sedimentary rock,

mainly sandstone and conglomerate, occurs in widely scattered localities. Bostock (1971) also outlines through early geological reports, the mining history of the area and some specific geological descriptions of the areas within the drainage.

The surficial geology of the area, including Big Creek drainage, has been discussed in Bostock (1971) and Hughes et al (1969). Hughes et al indicate that the majority of the Big Creek drainage lies beyond (above) the extent of the McConnell and Reid glacial advances during the Pleistocene. The Big Creek drainage basin is largely unglaciated, however remnant landforms attributed to the pre-Reid glacial interval are present. Surficial deposits in the older glacial land forms may include till deposits and glaciofluvial sediments (Morrison, S. pers. comm.).

1.2.4 Soils. No specific soil mapping studies have occurred in the immediate vicinity of the study area. General descriptions of soils and soil types of the Yukon are provided by Oswald and Senyk (1977). Soils of the major river channels of the Ecoregion are mostly Orthic Eutric Brunisols (moderately developed soils) developed on sandy or gravelly fluvial or silty eolian material over morainal deposits.

Oswald and Senyk (1977) comment that climatic factors appear to be the dominant soil forming process in the Yukon. Aspect plays a strong role in affecting local environmental conditions. In the low elevation drier areas, soils on steep south-facing slopes support grassy vegetation comunities interspersed with aspen and exhibit Brunisolic (moderately developed soils) development. In the same locality, soils on north-facing slopes are frequently perennially frozen, have hummocky surfaces and support open black spruce/moss vegetation communities. These general conditions are most noticeable in forested areas and apparent in the Big Creek valley. Silty material has a high water holding capacity and hence is readily frozen. The thaw or active layer in these deposits is often very shallow and the permafrost table is near the surface.

General observations by Oswald and Senyk (1977) for the relevant portion of the southern Yukon, reveals that Brunisolic soil development is common on a host of materials throughout the area. Regosols (poorly developed soils) are encountered on recent flood plains and on steep colluvium. Gleysols (water saturated soils) are frequently found adjacent to recent floodplains, bogs and on gentle seepage slopes. Organic soils are common in lowland areas and often have permafrost features such as peat plateaus and palsas. Cryosolic (soils containing permafrost) soils occur in both frozen lowland areas and in alpine areas.

1.2.5 Vegetation. General vegetation and forest type descriptions for the area are presented in Oswald and Senyk (1977) and Rowe (1972). Oswald (1983) has mapped and described vegetation in the area as far west as 137° to include the upper reaches of Seymour and Stoddart Creeks. Although the majority of the Big Creek drainage was not covered by Oswald (1983), much of the information and general nature of the vegetation can be extended to include most of the study area.

Plant communities throughout the drainage vary according to soil drainage, elevation, aspect and disturbances. Communities vary with elevation largely due to climatic changes in relation to elevation so that boreal montane communities are present at lower elevations but grade through sub-alpine to alpine communities. Northerly aspects are generally colder and have lower evapotranspiration ratios than southerly aspects which give rise to variance in vegetation communities.

The vegetation can be partitioned into 3 broad zones: alpine, subalpine and boreal montane, largely due to topographic position and resulting climate. The alpine zone generally occurs above 1370 m in the area of Big Creek. The subalpine zone occurs below the alpine zone down to approximately 1200 m, generally being higher on south aspects than on north aspects. The boreal montane zone is most extensive, occurring below 1200 m.

The alpine zone vegetation is characterized by low to prostrate shrubs and numerous lichens with variable amounts of grass,

graminoids, forbs and byrophytes. The vegetation cover and species composition varies greatly. Included are: exposed, usually dry sites where vegetation is sparse (10%-70% cover); level or gently sloping sites with some topographic protection where typical alpine vegetation occurs (70%-100% cover) and; nutrient rich, perpetually moist and topographically protected sites where herb rich meadows occur.

The subalpine zone is characterized by medium to low height shrubs in the upper range and by scattered to open tree communities in the lower range. The criteria for inclusion in this zone in the Big Creek area would be that the stand be relatively stable and that the combined cover of willow and shrub birch be greater than that of the combined coniferous tree species. In the Big Creek area, white spruce is the principal species but black spruce may also be present particularly on north aspects.

The boreal montane zone contains a large number of communities due to terrain variation and fire history. The most frequent mature vegetation consists of white spruce/feather moss except on north aspects that contain permafrost which supports white spruce-black spruce/Labrador tea/brown moss. The coarse textured outwash material in most valley bottoms is rapid to excessively drained, resulting in droughty soils. White spruce forms the stable vegetation but it is usually quite open and grass, kinnickinnick and lichens are the most common understory species. Steep, south aspect banks support grasses in association with kinnickinnick. Other dry habitat species are associated with this restricted habitat. Aspen tends to encroach on the grassland in more moist sites and extends by reproduction in its own shadow. Recent alluvium occurs along most drainages and constitutes the most productive sites. The stable vegetation usually consists of white spruce/feather moss, but horsetail and rose frequently occur before feather moss develops. Grey alder sometimes provides significant cover with willow under balsam poplar. Additional details on species and community composition is given in Oswald (1983).

2 LAND USE ACTIVITIES

The study area incorporates a portion of the Big Creek watershed centering on the mainstem of Big Creek and two of its three major tributaries (Figure 3) Stoddart and Seymour Creeks. This portion of the watershed has been the focus of the majority of placer and hard rock exploration activity. The other major land use in this area, road construction and maintenance, is directly related to the mining and mineral exploration activity. Little verifiable information is known about recreational and hunting use in the area, however, it is believed that levels of use are low and very much incidental. There is one site specific land claim selection based on historical features, in the study area (Figure 3).

2.1 Mining Activities

2.1.1 Mineral Activity

The first interest in this area was generated by a small gold stampede in 1917 into the valley of Seymour Creek. Although no substantial finds were made during this period, it did stimulate the continuing interest of a few local prospectors. This interest paid off with a lode gold strike on the ridge north of Seymour creek in 1930. This strike renewed interest in this area and over 100 quartz claims were staked by the beginning of 1931. This activity was mainly centred on the area of the ridge forming the north side of Seymour Creek valley. Some claims were allowed to lapse by 1932 as no other major finds materialized. There were, however, sufficient mineral showings to maintain a reduced level of interest in the area (Bostock, 1977). The Freegold Mine went into production for a short period of time in the 1930's and again in the mid 1960's. Since then there have been no active mines in the area. However, with the rise in gold and metal prices in the late 1970's and early 1980's, interest was revived again. Considerable exploration drilling and trenching has taken place on mineral claims in the area. Appendix II outlines the area covered by active quartz claims.

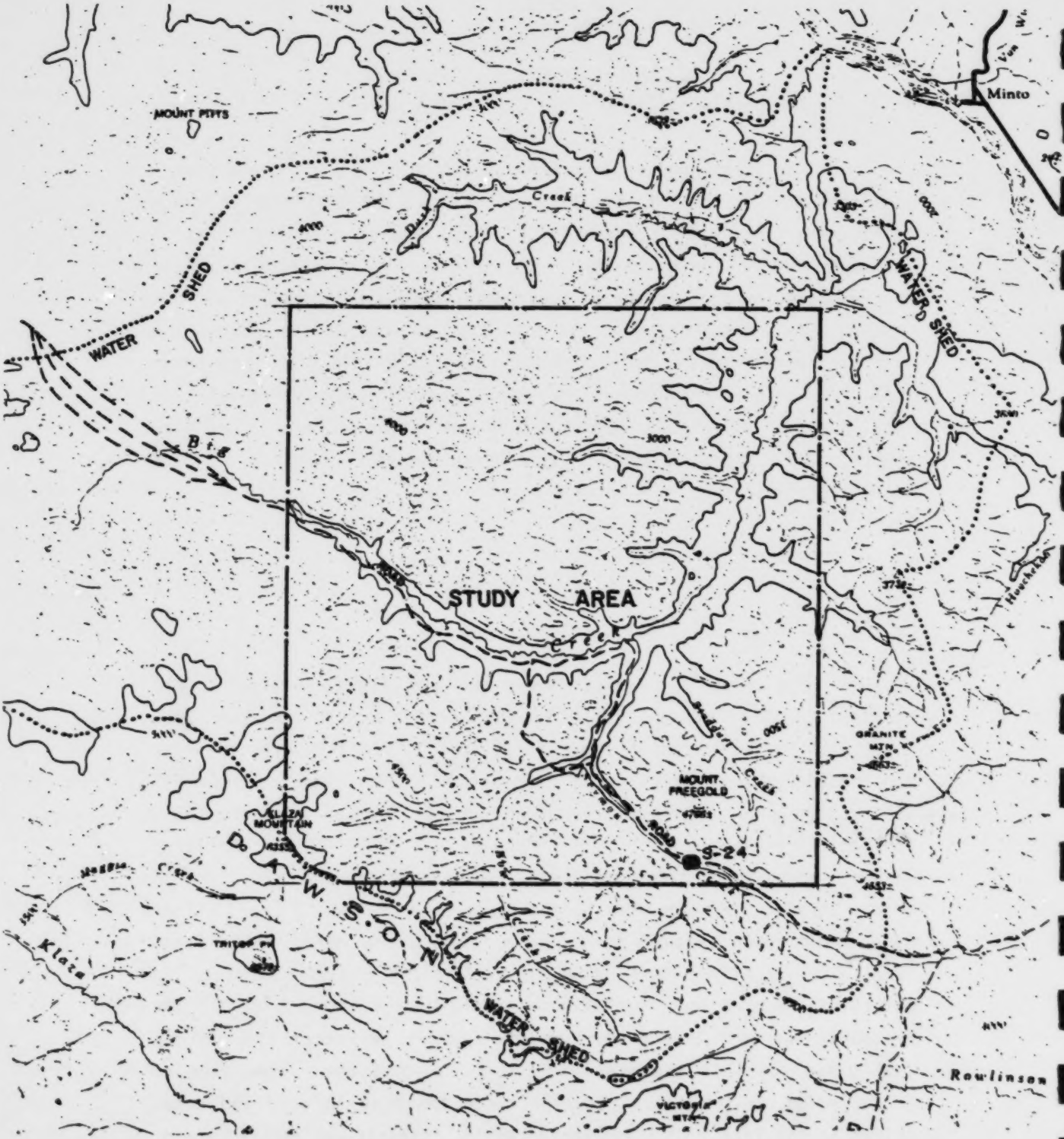


FIGURE 3 LOCATION OF WATER SHED BOUNDARY, ROAD ACCESS AND SITE SPECIFIC LAND CLAIM SELECTION WITH RESPECT TO THE STUDY AREA.

2.1.2 Placer Activity

Placer activity which appeared to have been centred around Stoddart and Seymour Creeks in the 1930's has gradually moved west to include the other tributaries on the south side of Big Creek. Activity was documented on Mechanic and Revenue Creeks in 1964. There are now active placer claims or leases on Magman, Noname, Mechanic, Revenue, Boliden, Happy, Tara, Seymour, Bow and Stoddart Creeks (Figure 4 and Appendix II). With the decline in gold prices, activity has again started to drop. Table 2 indicates those operations with active claims actually operating in 1984. This number is likely to decrease even further in 1985 (Gilbert pers. comm.).

2.1.3 Road Development

As a result of the operation of the Freegold Mines and the long term prospecting and exploration activity in this area, there is a well developed road system (Figure 3) from the Highway at Carmacks. The road system permits two wheel drive along the old Freegold Road from the highway to the junction of Bow Creek and Seymour Creek. Four wheel drive is required for the switchback up to Revenue Creek Hill reverting to fairly good two wheel drive through the study area paralleling Big Creek. Side roads cut off the main road to access the creeks.

Early road construction occurred before the land use permit system was in place. More recent construction and upgrading has occurred under permit except on claim areas.

2.2 Disturbance Level

In comparison to other placer mining areas, the Big Creek watershed is relatively undisturbed, with operations being generally quite small. Hard rock activity since the closure of the Freegold Mine in the mid 1960's has been primarily exploration work, with the major

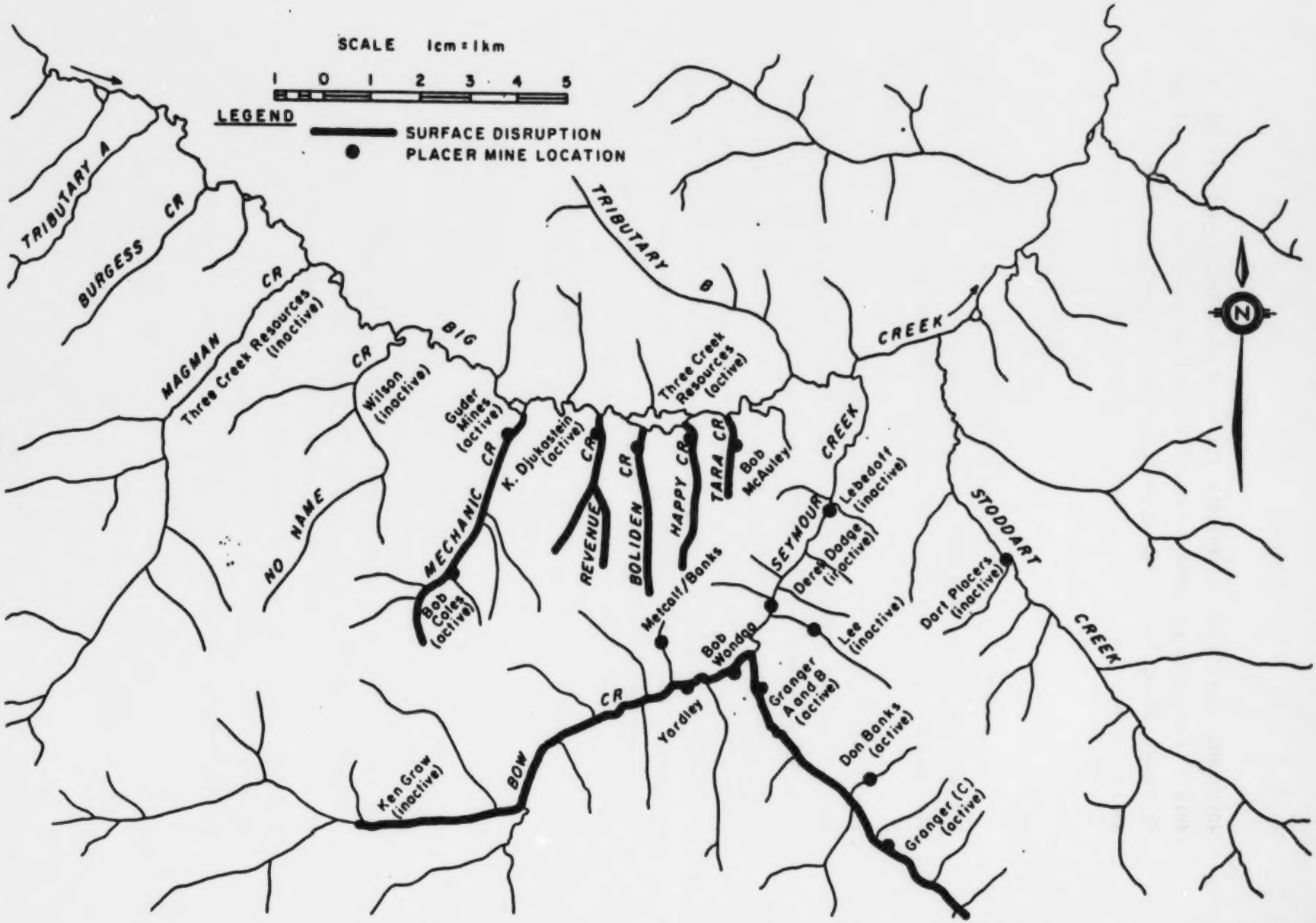


FIGURE 4 LOCATION OF VARIOUS PLACER MINING OPERATIONS IN THE BIG CREEK STUDY AREA, 1984.

TABLE 2 PLACER MINING ACTIVITY - BIG CREEK STUDY AREA, 1984

OPERATION*	LOCATION	1984 ACTIVITY	NO. OF SETTLING PONDS
Dart Placers	Stoddart Creek	Inactive	None
Lebedoff**	Seymour Creek	Inactive	None
Dodge	Seymour Creek	Some stripping	1
Lee**	Trib. to Seymour Cr.	Some drift mining	None
Granger	Seymour Cr. (Site A and B)	Active	1
Granger	Seymour Cr. (Site C)	Active	1
Banks	Cabin Gulch (Trib. to Seymour Cr.)	Active	1
Wondga	Bow Cr.	Inactive	1
Yardley**	Bow Cr.	Some stripping	None
Metcalf/Banks**	Trib. to Bow Creek	Inactive	None
Graw	6804 Cr. - Trib. to Bow Creek	Inactive	1
McAuley	Tara Creek	Active	2
Three Creek Resources	Happy Creek	Active	2
J-Nor Ent.**	Happy Creek	Inactive	None
Three Creek Resources	Bolliden Creek	Active	5
Djukastein	Revenue Creek	Active	2
Guder Mines	Mechanic Creek	Active	2
Coles	Mechanic Creek	Active	2
Wilson**	Noname Creek	Inactive	None
Three Creek Resources	Magman Creek	Inactive	None

*Operation may be leased on a particular claim
**Operation without a water licence

impact being visual (trenching, cut lines, etc.). With the limited land uses in the watershed, it is likely that any "above background" level of sediment load, metals, etc. is due to the placer activity and related road access. However, the lack of premining information on these background levels or on their natural fluctuations due to spring runoff, rain storms and other natural phenomena make it difficult to ascertain the extent of change due to placer activity and to monitor the impact of various levels of disturbance on water quality or to monitor the success of different control mechanisms. This predictive capability is further reduced by the lack of a control stream.

Government regulatory agencies have not measured key variables, been involved in experiments with different mining techniques, different development plans or with rehabilitation techniques.

a) There is virtually no information on the soils in the area and limited information on the surficial geology.
b) There has been no calculation of the extent of area within the watershed which has been disturbed. Recent aerial photography will be required before this can be measured.
c) There has been no attempt to characterize disturbed areas as to environmental site conditions, such as slope, soil characteristics, proximity to stream banks, etc. There has been no correlation between these site conditions, activity types or levels with water quality, sediment loads, benthic populations or fishery populations and/or habitat.

2.3 Summary and Recommendations

If land related concerns are to be an integral part of management of the conflicts between placer mining, fisheries, water quality and other resources and resource users, there is a need to understand those key environmental variables and how an area will react to different types and levels of activities. Some examples of potential key environmental variables are: slopes; channel structure; stream gradient; soil type; presence of permafrost. This requires more indepth study than has taken place to date. Once collected this infor-

mation could be used to determine mitigative measures, rehabilitation requirements and, in conjunction with other resource information (i.e. fisheries, water quality) to determine standards for discharge.

However, before this study area is chosen for a long time project, the site conditions must be established and the differences between this area and others must be evaluated to determine how or whether the information generated in such a study could be transferred to other areas.

3 METHODS, OBSERVATIONS AND RESULTS

The field investigation and report preparation for "An Environmental Overview Of Big Creek, Yukon As Related To The Placer Mining Activity" was a joint inter-departmental venture. Information concerning water quality and quantity was collected and prepared by the Water Resources Division of DIAND. The fish inventory was completed by the Whitehorse office of the Department of Fisheries and Oceans and the benthic invertebrates and sediment characteristics information was compiled and prepared by Environment Canada, Environmental Protection Service, Yukon Branch. All raw data from these investigations appear as Tables in the Appendices in Volume II of this report.

Environmental Protection Service office staff and personnel were responsible for assimilating the various sections and editing the report as a unit. The Reference List of this report has been separated into different sections as outlined by the structure of the report.

3.1 Water Quality and Quantity

3.1.1 Introduction

Water quality and stream flow information on Big Creek was gathered by the Department of Indian Affairs and Northern Development (DIAND), Water Resources Division as part of their contribution to the Big Creek Environmental Assessment Project. In addition, all placer operations within the Big Creek study area were routinely inspected by DIAND water management staff to ensure that all water use was undertaken in compliance with the Northern Inland Waters Act (NIWA) and NIWA Regulations.

The mainstem of Big Creek is a relatively undisturbed water system, with placer mining activity limited to the small tributaries located upstream of Stoddart Creek (Figure 2). Twenty placer mining operations were located within the study area, eleven of which were active at some point during the study period (Table 2). The Seymour Creek sub-basin has the largest number of placer claims with six operators. The most active placer operations in the study area were located on Seymour and Revenue Creeks.

This watershed was previously studied to determine the effects of placer mining, and to inventory resources present. Burns (1980), performed an indepth analysis of water quality, stream sediments and benthic invertebrates in Big Creek. Mathers et al (1981) gave an overview of the fish and wildlife resources present in the Big Creek drainage area. Based on these two reports, the water quality of this northern stream was found to be similar to other Yukon streams with no metal contamination detected in water or sediment (Mathers et al, 1981).

In this study the Big Creek area was visited on three separate occasions; July 23-26, August 13-16 and September 17-19, 1984. Six water quality stations were established on the mainstem of Big Creek, with an additional station on Stoddart Creek. All tributaries flowing into Big Creek were monitored for suspended solids. A few sampling stations were accessible by road, the remainder required helicopter support.

3.1.2 Methods

Placer Mining Inspection Sampling

Within the Big Creek watershed, all placer mining operations were routinely inspected by DIAND Water Management Officers (WMO) and water samples were collected to determine if effluent water quality objectives were being attained. Mining inspections were conducted during the active placer season, usually between May and September. Standard locations where water samples were collected include the receiving water upstream of the operations, settling pond effluent, receiving water approximately 100m downstream of the effluent discharge after mixing has occured and occassionally sluicebox outflow.

Nalgene (1 litre) sample bottles were rinsed three times before sample collection and the samples were stored unpreserved in coolers on route to the DIAND laboratory in Whitehorse. Sample number, location, date, and time of collection were marked directly on the container.

In the DIAND laboratory, water samples were usually analyzed within a week of collection for NFR (suspended solids), turbidity, settleable solids, pH and conductivity according to methods outlined in Standard Methods for the Examination of Water and Wastewater (APHA-AWWA-WPCF, 1980). Water clarity was measured with an Allied Colloids clarity wedge. Occasionally the WMO performed on site settleable solid tests with an Imhoff cone using methods outlined in the Department of Environment, (1979) Laboratory Manual.

Flow Measurements

Flow measurements were taken in stable areas at all Big Creek mainstem and tributary stations simultaneously with water quality and benthic collection. Flow was measured at each station on all three sampling occasions. A Price-type AA current meter wading rod was used to measure the instantaneous velocity at a minimum of 20 vertical points in the stream's cross-section wherever possible. The midsection method was then used to calculate stream discharge.

Daily total discharge of Big Creek at the mouth for 1984 was obtained from a Water Survey of Canada continuous guaging station (station no. 09AH003) located 37 km downstream of Big Creek Station 6. Daily and monthly discharges calculated for Big Creek during 1984 have not yet been verified for publication.

Water Quality Sampling and Analysis

Three types of water quality sampling stations were established during the Big Creek study (Figure 5). These include detailed chemistry, tributary sediments and automatic sequential sampling stations. The six mainstem stations and the lone Stoddart Creek station were sampled for detailed water chemistry. Nine tributary stations were sampled across a transect for suspended solids, and the four automatic sequential samplers monitored suspended solids

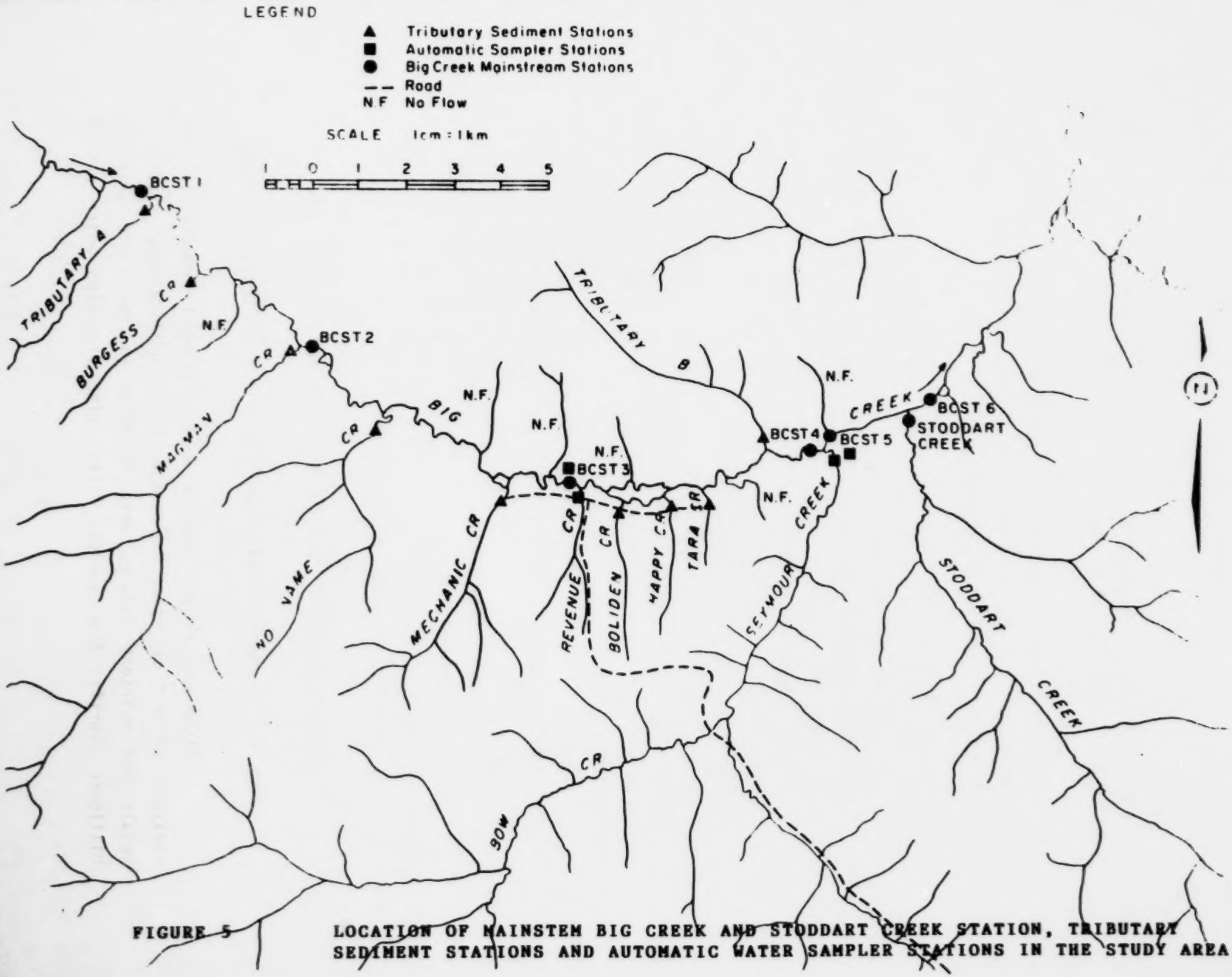


FIGURE 5 LOCATION OF MAINSTEM BIG CREEK AND STODDART CREEK STATION, TRIBUTARY SEDIMENT STATIONS AND AUTOMATIC WATER SAMPLER STATIONS IN THE STUDY AREA.

concentrations on Big Creek and on two placer streams over a 24 hour period. All stations were sampled in the same manner on each field trip.

Water quality samples for detailed chemical analysis were collected at the six Big Creek mainstem stations and the Stoddart Creek control station (Table 3) as follows:

i) Nutrients (includes NFR, FR, pH, conductivity, turbidity, alkalinity, SO_4, and Cl) - 2 litres, unpreserved.

ii) Dissolved nutrients (NO_2, NO_3, Cl, SO_4, total PO_4) - 250 ml unpreserved.

iii) Total metals and hardness - 100 ml, preserved.

Aluminum (Al)	Cobalt (Co)	Selenium (Se)
Antimony (Sb)	Copper (Cu)	Silica (Si)
Arsenic (As)	Iron (Fe)	Sodium (Na)
Barium (Ba)	Lead (Pb)	Strontium (Sr)
Boron (B)	Magnesium (Mg)	Tin (Sn)
Cadmium (Cd)	Manganese (Mn)	Titanium (Ti)
Calcium (Ca)	Molybdenum (Mo)	Vanadium (V)
Chromium (Cr)	Nickel (Ni)	Zinc (Zn)

iv) Dissolved metals and dissolved hardness - 100 ml, filtered and preserved,

v) Total Mercury - 100 ml, preserved

vi) Dissolved Oxygen - 2 x 300 ml, preserved

vii) NFR, pH, conductivity, turbidity - 3 x 1 litre, unpreserved

Dissolved oxygen samples were preserved immediately and analyzed the next day using the Winkler Azide Modification. Dissolved metals and nutrient samples were filtered in the field using a Millipore Sterifil 47mm aseptic filter with distilled water washed

TABLE 3 DESCRIPTION OF SAMPLE SITES ON MAINSTEM BIG CREEK AND STODDART CREEK

STATION	LOCATION	DESCRIPTION
1	62°24'N 137°26'W on Big Creek, 4.4 (air)km upstream of Station 2 and 15.6 (air) km upstream of Seymour Cr. Elevation 747m.	Right bank slumping, 3m high, left bank gravel bar 1m high slope. Vegetation consists of 30% shrub, 10% deciduous, 60% coniferous, 10% shade.
2	62°23'N 137°24"W on Big Creek, 6.1 (air)km upstream of Station 3 and 11.2 (air) km upstream of Seymour Cr. Elevation 695 m.	Right bank gravel bar, 1m high slope, left bank slumping, 2m high, vegetation consists of 20% shrub, 10% deciduous, 70% coniferous, 15% shade.
3	62°21'N 137°16'W on Big Creek, 5.1 (air)km upstream of Seymour Creek. 100m upstream of Revenue Creek. Elevation 662 m.	Right and Left bank, 0.5 m high stable slope. Vegetation consists of 45% shrub, 10% deciduous, 45% coniferous, 5% shade.
4	62°21N 137°10'W on Big Creek, 20 m upstream of Seymour Creek. Elevation 625 m.	Right bank slumping, 0.5 m high, left bank, gravel bar 0.5 m high. Vegetation consists of 30% shrub, 10% deciduous, 60% coniferous, 15% shade.
5	62°21'N 137°10'W on Big Creek, 50 m downstream of Seymour Creek. Elevation 620 m.	Right bank slumping, 2m high, left bank gravel bar 1m high. Vegetation consists of 40% shrub, 10% deciduous, 50% coniferous, 10% shade.
6	62°21'N 137°09'W on Big Creek, 2.1 (air)km downstream of Seymour Creek. Elevation 610 m. 37 km upstream of confluence with Yukon River and Big Creek.	Left and right bank gravel bar, 0.5m high. Vegetation consists of 50% shrub, 40% deciduous, 10% coniferous, 5% shade.
Stoddart Creek Station	62°21'N 137°09'W on Stoddart Creek, 50 m above the confluence of Stoddart Creek and Big Creek. 2.0 (air)km downstream from Seymour Creek. Elevation 610 m.	Right bank .2m high, slumping, left bank 1m high gravel bar. Vegetation consists of 70% shrub 30% coniferous, 60% shade.

Millipore HA 0.45u type filters. In situ measurements of temperature (standard centigrade thermometer), pH (Corning pH meter 30), and conductivity (YSI conductivity Meter Model 33) were made at Big Creek and Stoddart Creek stations.

At the nine tributary sediment stations (Table 4), three replicate samples were collected in one litre polyethylene bottles along a transect of the stream width looking downstream and labelled left bank (L.B.), center (C), and right bank (R.B.). These replicate samples were analyzed for non-filterable residue, pH, turbidity and conductivity. It should be noted that 3 one litre replicate NFR samples collected at the detailed chemistry stations were sampled along a transect of the creek in the same manner as the sediment stations.

Automatic sequential water samplers (ISCO Model 1640, Instrumentation Specialties Company) were positioned at four different locations within the study area (Table 5). Water samples were collected in 500 ml plastic bottles at one-hour intervals for a period of 24 hours. The intake hose of the sampler was extended as far into the center of the stream as possible and positioned below the water surface. For comparison purposes, the four automatic samplers were started within 1 to 2 hours of each other. The samples collected were analyzed for NFR, pH, conductivity and turbidity.

Appendix III, Table 1, describes water sample collection, preservation and analysis or identification methods used. All water samples collected at the detailed chemistry and tributary sediment stations, were subsurface samples. Samples were sent in coolers to the Environmental Protection Service, West Vancouver Laboratory within four days of collection.

3.1.3 Results and Discussion

Placer Mining Inspection Results

Figure 4 illustrates the location of the placer mining operations within the Big Creek study area. All placer operations were

TABLE 4 TRIBUTARY SUSPENDED SOLID SAMPLING STATIONS

STATION	LOCATION	DESCRIPTION
Tributary A	Located 50m downstream of Big Creek Station 1. Sampled at mouth of creek.	No activity on Tributary A.
Burgess Creek	Located 3.0 km dowsntream of Big Creek Station 1. Sampled at mouth of creek.	No activity on Burgess Creek.
Magman Creek	Located 0.7 km upstream of Big Creek Station 2. Sampled 0.8 km upstream of mouth of creek.	No placer activity on Magman Creek in 1984.
Noname Creek	Located 4.1 km downstream of Big Creek Station 2. Sampled at road crossing 0.1 km upstream of mouth.	No placer activity on Noname Creek in 1984.
Mechanic Creek	Located 4.6 km upstream of Big Creek Station 3. Sampled at road crossing 0.1 km upstream of mouth.	Two active placer operations on Mechanic Creek.
Bolliden Creek	Located 1.8 km downstream of Big Creek Station 3. Sampled at road crossing 50 m upstream of mouth.	One active placer operation on Bolliden Creek.
Happy Creek	Located 3.3 km downstream of Big Creek Station 3. Sampled at road crossing 0.1 km upstream of mouth.	One active placer operation on Happy Creek.
Tara Creek	Located 4.6 km downstream of Big Creek Station 3. Sampled at road crossing 0.1 km upstream of mouth.	One active placer operation on Tara Creek.
Tributary B	Located 1.8 km upstream of Big Creek Station 4. Sampled 0.1 km upstream of mouth.	No activity on Tributary B.

TABLE 5 AUTOMATIC SEQUENTIAL (ISCO) SAMPLING STATIONS

STATION	LOCATION	DESCRIPTION
Automatic Sampler #1 (A.S. #1)	Seymour Creek	On left bank 100 m upstream Seymour-Big Creek confluence. Placer operation 6.5 km upstream of sampler.
Automatic Sampler #2 (A.S. #2)	Big Creek Station 5	On right bank 50m downstream Big-Seymour Creek confluence. Adequate mixing thought to occur.
Automatic Sampler #3 (A.S. #3)	Revenue Creek	Sampler 50 m downstream of settling facility. Road crossing upstream of sampler.
Automatic Sampler #4 (A.S. #4)	Big Creek Station 3	On right bank 200m upstream of Big-Revenue Creek confluence. 7km upstream of A.S. #2

located on tributaries on the southern slope of the Big Creek valley. The most active placer operations were on Seymour and Revenue Creeks.

Water samples were collected from five operations in the Big Creek area, from May 29-September 17, 1984. Samples were collected at one placer operation on Seymour Creek on nine separate occasions, while placer operations on Revenue Creek, Mechanic Creek and Cabin Gulch were sampled once for effluent quality.

Limited data precludes any direct comparisons between effluent water quality at the various placer operations in the study area, however, a few observations can be made about suspended solid results (Figures 6 and 7) as follows:

i) Background suspended solids concentrations were consistently low at all operations (range 1.0 mg/l - 31 mg/l);

ii) Effluent suspended solids concentrations were 50 to 500 times greater than background levels at all operations, even if sample collection occurred when sluicing was not in progress;

iii) Downstream suspended solids concentrations were 7 to 220 times greater than background levels on Seymour Creek (Figure 6), and 37-40 times greater than background levels on Mechanic Creek (Figure 7) when sluicing was in progress.

iv) Effluent suspended solids concentrations on Seymour Creek were lower when sluicing was not in progress, and substantially lower when the operation was shut down on September 17, 1984.

Volume II, Appendix I contains all water quality data collected during site inspection at the various placer operations in the Big Creek study area in 1984.

Flow Measurements

Daily total discharge at the mouth of Big Creek (Water Survey of Canada Station No. 09AH003) for June, July, August and September of 1984 and Big Creek sampling periods are illustrated in Figure 8. Most noteworthy was the August sampling period which coincided with a summer rain event. Mean monthly Big Creek discharge (May-September) for the period 1975 to 1984 are listed in Table 6. Peak flows usually occur in

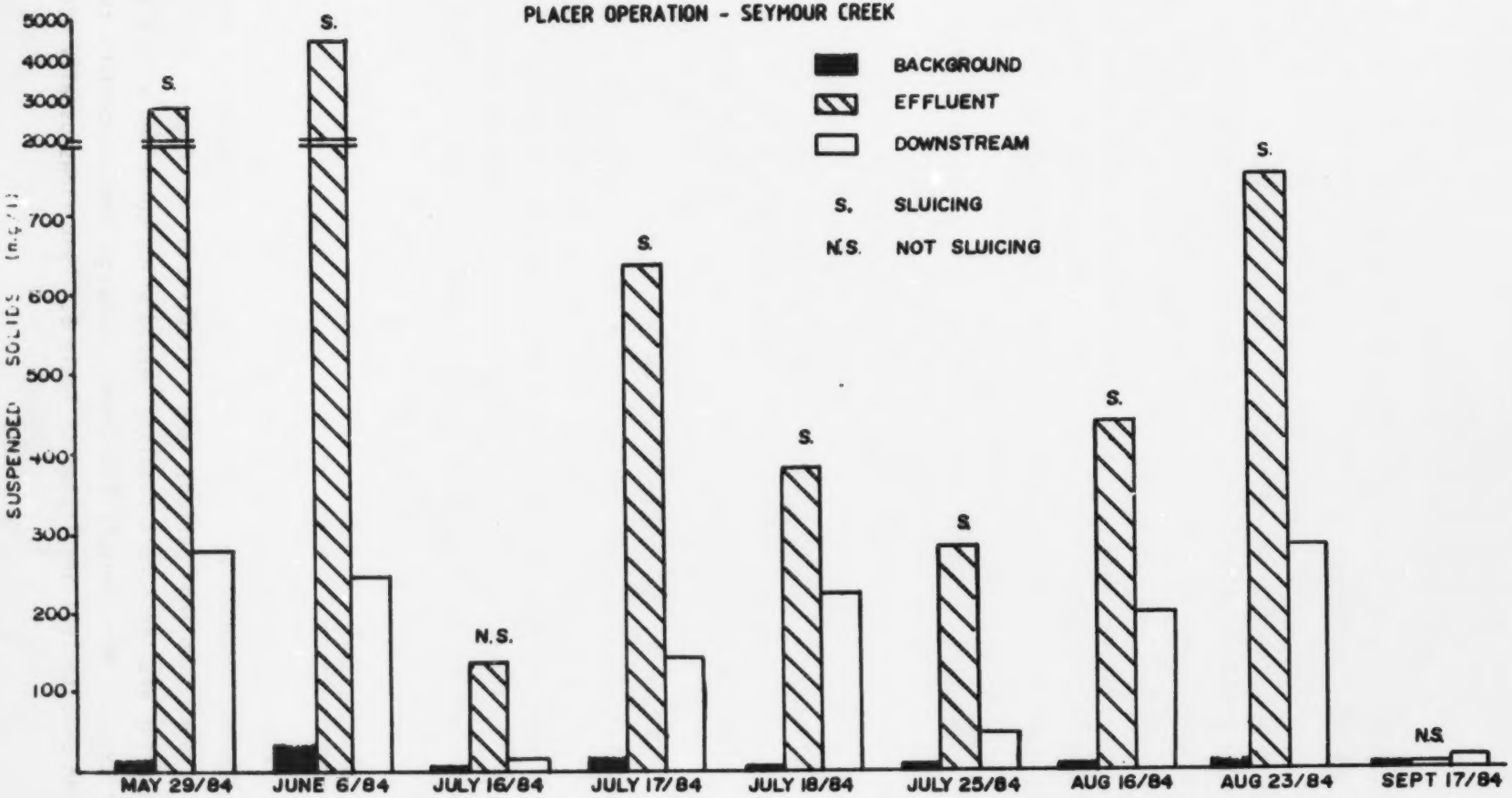


FIGURE 6 SUSPENDED SOLIDS DATA AT A PLACER MINING OPERATION ON SEYMOUR CREEK, 1984.

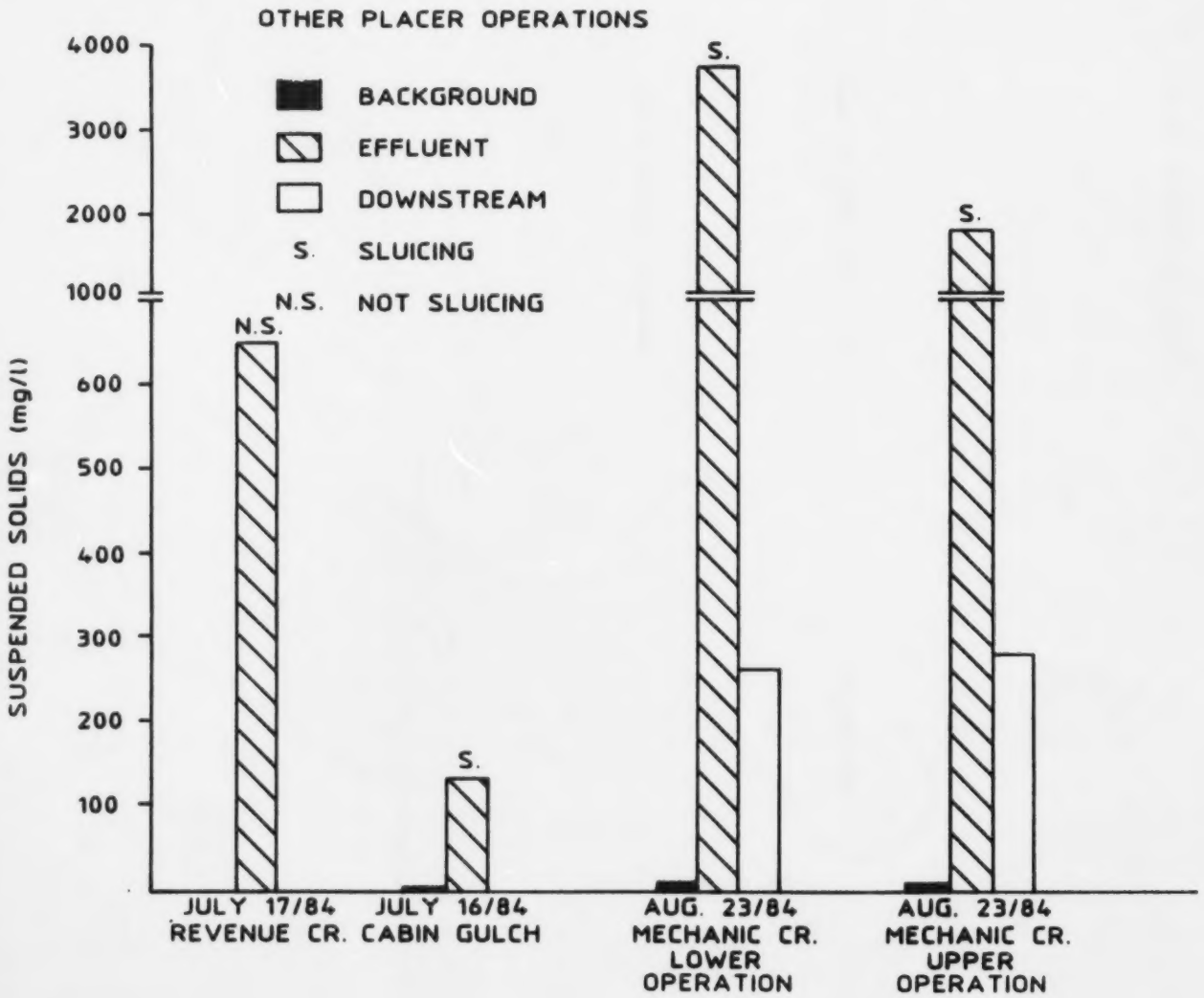


FIGURE 7 SUSPENDED SOLIDS DATA AT PLACER MINING OPERATIONS ON MECHANIC AND REVENUE CREEKS AND CABIN GULCH, 1984.

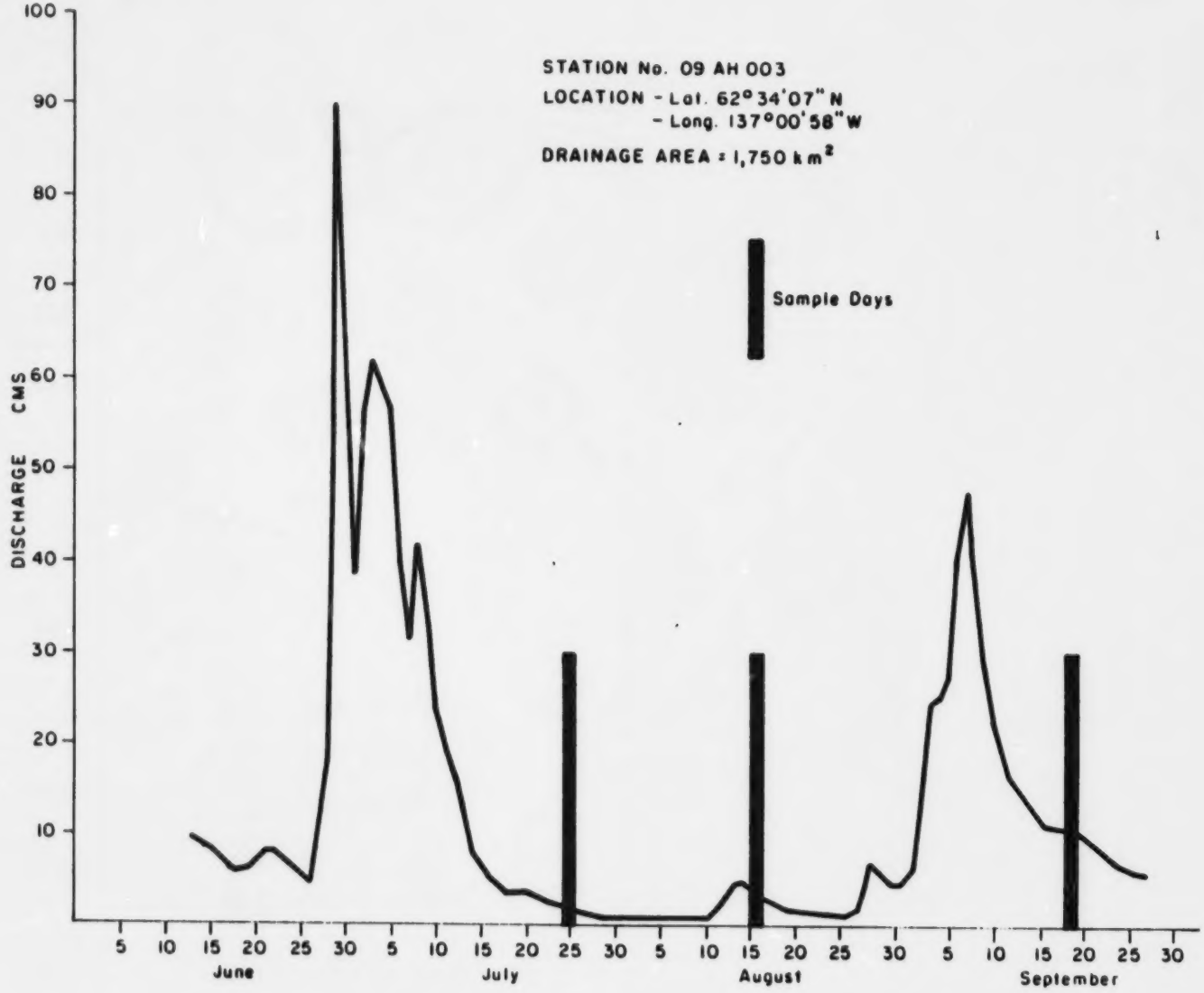


FIGURE 8 DAILY TOTAL BIG CREEK DISCHARGE AT MOUTH, FOR SUMMER, 1984
WATER SURVEY OF CANADA.

TABLE 6 MEAN MONTHLY DISCHARGE (M^3/SEC) FOR BIG CREEK (ENVIRONMENT CANADA 1982, 1983)

YEAR	MONTH				
	MAY	JUNE	JULY	AUGUST	SEPTEMBER
1975	37.3	14.6	23.9	23.1	13.8
1976	23.4	25.7	42.5	5.94	2.92
1977	17.6	17.9	15.8	3.92	4.28
1978	7.04	20.8	40.1	23.4	7.72
1979	18.0	18.4	19.6	12.0	10.3
1980	7.8	4.7	16.6	11.0	22.1
1981	12.8	4.72	18.4	14.0	5.89
1982	24.0	20.1	4.88	16.0	2.73
1983	8.49	21.3	17.9	27.3	8.89
*1984	--	16.4	17.5	2.41	16.6

*1984 data not verified for publication.

spring to early summer, with lower flows ocurring in late summer. In 1984, a large flow was observed in September caused by an early snowfall coupled with major rain events. Mathers et al (1981), observed similar patterns during their 1980 study.

Flow, in cubic metres per second (cms), measured at the Big Creek mainstem stations, the Stoddart Creek station and all tributary sediment stations during the three sampling periods are contained in Table 7. Within the study area, the largest flows were observed during the September 18 sampling period at all stations, with the exception of Revenue Creek. Natural flows on Revenue Creek were increased during the placer season because of a water diversion located 200m upstream of Big Creek Station 3 (BCST 3). The additional water was required from Big Creek for the placer operation located on Revenue Creek. The flow measured on Revenue Creek on September 18 (0.0080 cms) would be representative of natural instream flow as no water was being diverted into it at this time. Flows were not measured at the water diversion during this study, however, on June 6, 1984, a flow of 0.54cms was recorded by the WMO inspecting the diversion.

The lowest flows were recorded for most stations in July with the exception of Tributary A and Magman Creek which had larger flows in July than August. The metering of some smaller tributaries is questionable, due to stream width, since the flows calculated may be inflated from the reduced number of cross-sectional stream velocity measurements.

Water Quality

Detailed water quality data developed during this study are presented in Volume II, Appendices II, III and IV. Water quality in the mainstem of Big Creek and Stoddart Creek will be discussed by parameter groupings, whereas the separate discussion on suspended solids will include results from the following stations:

- mainstem Big Creek and Stoddart Creek stations;
- all tributary suspended solid stations; and
- automatic water sampler stations.

TABLE 7 FLOW MEASUREMENTS BIG CREEK STUDY AREA.

JULY, AUGUST & SEPTEMBER

STATION	FLOW (CMS)		
	JULY	AUGUST	SEPTEMBER
Big Creek St. 1	1.82	1.93	4.07
Tributary A	0.040	0.018	0.251
Burgess Creek	0.0060	0.020	0.029
Magman Creek	0.073	0.030	0.085
Big Creek St. 2	1.89	2.13	4.47
Noname Creek	0.014	0.026	0.063
Mechanic Creek	0.014	0.033	0.070
Big Creek St. 3	1.75	1.48	4.51
Revenue Creek	0.189	0.273	0.0080
Bolliden Creek	0.00050	0.0080	0.0050
Happy Creek	0.0010	0.0040	0.0160
Tara Creek	0.0010	0.0020	0.0040
Tributary B	NIL	NIL	0.092
Big Creek St. 4	2.33	2.51	4.98
Seymour Creek	0.865	1.15	1.84
Big Creek St. 5	3.30	3.75	6.84
Stoddart Creek	0.310	0.639	0.634
Big Creek St. 6	3.81	4.27	6.83

Big Creek and Stoddart Creek Water Quality. Mean water quality data for the six stations on the mainstem of Big Creek for is each sampling period presented in Table 8. All parameters with thety exception of turbidi and certain metals, were within the life recommended levels for aquatic and drinking water standards (Appendix III, Table 4).

i) Physical Parameters

Water temperatures in Big Creek and Stoddart Creek were highest during the July sampling trip. Water temperatures in Stoddart Creek were generally lower than Big Creek. The parameter pH, showed little variation between stations or sample periods.

Specific conductance, a general indicator of the concentration of dissolved substances present in water, varied with station location and sample period. Figure 9 illustrates the spatial and temporal variations in specific conductance. Conductivity values were stable in the headwater stations (Big Creek Station 1 to Big Creek Station 3) and then increased at Big Creek Station 5 during all sample periods. This increase at Big Creek Station 5 was due to the influence of Seymour Creek, which had a specific conductance of approximately 210 umhos/cm during all sample trips. Specific conductance was elevated at all stations during the August sample period and may be attributable to the influence of water from ground water sources or surface runoff. Specific conductance on Stoddart Creek decreased from 141 umhos/cm in July to 119 umhos/cm in September.

Compared to results determined by Mathers et al (1981), mean specific conductance in Big Creek was lower in July (116 $\pm$ 49 umhos/cm) and September (129 $\pm$ 5 umhos/cm), than in July (139 $\pm$ 7.5 umhos/cm) and September (147 $\pm$ 14 umhos/cm) 1984, although Mather's results were for the total Big Creek drainage.

Turbidity concentrations were low (0.10 F.T.U.) at the headwater stations during all sample periods, and generally increased at downstream stations. The highest turbidity concentration (21.0 F.T.U.) was observed in July at Big Creek Station

TABLE 8 MEAN VALUES (± S.D.) FOR WATER QUALITY PARAMETERS ON BIG CREEK IN JULY, AUGUST AND SEPTEMBER, 1984

PARAMETER	SAMPLING PERIOD		
	JULY 24	AUGUST 14	SEPTEMBER 18
PHYSICAL PARAMETER			
Temperature (°C)	11.2 ± 0.7	8.3 ± 2.7	3.4 ± 1.0
pH (Units)	7.4 ± 0.1	7.6 ± 0.1	7.5 ± 0.1
Conductivity(umhos /cm)	139 ± 8	159 ± 12	147 ± 14
Turbidity (F.T.U.)	9.3 ± 7.4	10.5 ± 7.1	5.0
F.R. (mg/l)	109 ± 5.9	125 ± 8.9	120 ± 8.0
OTHER PARAMETERS (mg/l)			
T. Alkalinity	57.5 ± 4.0	65.3 ± 5.1	60.5 ± 5.5
T. Hardness	70.4 ± 7.4	74.7 ± 12.1	73.2 ± 7.6
D. Hardness	60.6 ± 4.2	69.4 ± 6.3	61.6 ± 7.8
T. Sulphate	9.2 ± 0.8	10.8 ± 1.5	8.0 ± 1.1
D. Sulphate	9.3 ± 0.8	11.2 ± 1.6	9.0 ± 1.1
T. Chloride	0.7 ± 0.1	1.5 ± 0.1	0.70 ± 0.04
D. Chloride	0.6 ± 0.1	0.60 ± 0.2	0.60 ± 0.1
D. Phosphate	0.0090 ± 0.002	0.018 ± 0.010	0.0070 ± 0.002
D. Nitrite	0.0050	0.0050	0.0050
D. Nitrate	0.050 ± 0.02	0.080 ± 0.03	0.10 ± 0.04
D. Oxygen	9.7 ± 0.5	10.7 ± 0.7	11.3 ± 0.4

T = Total
D = Dissolved
S.D.= Standard Deviation

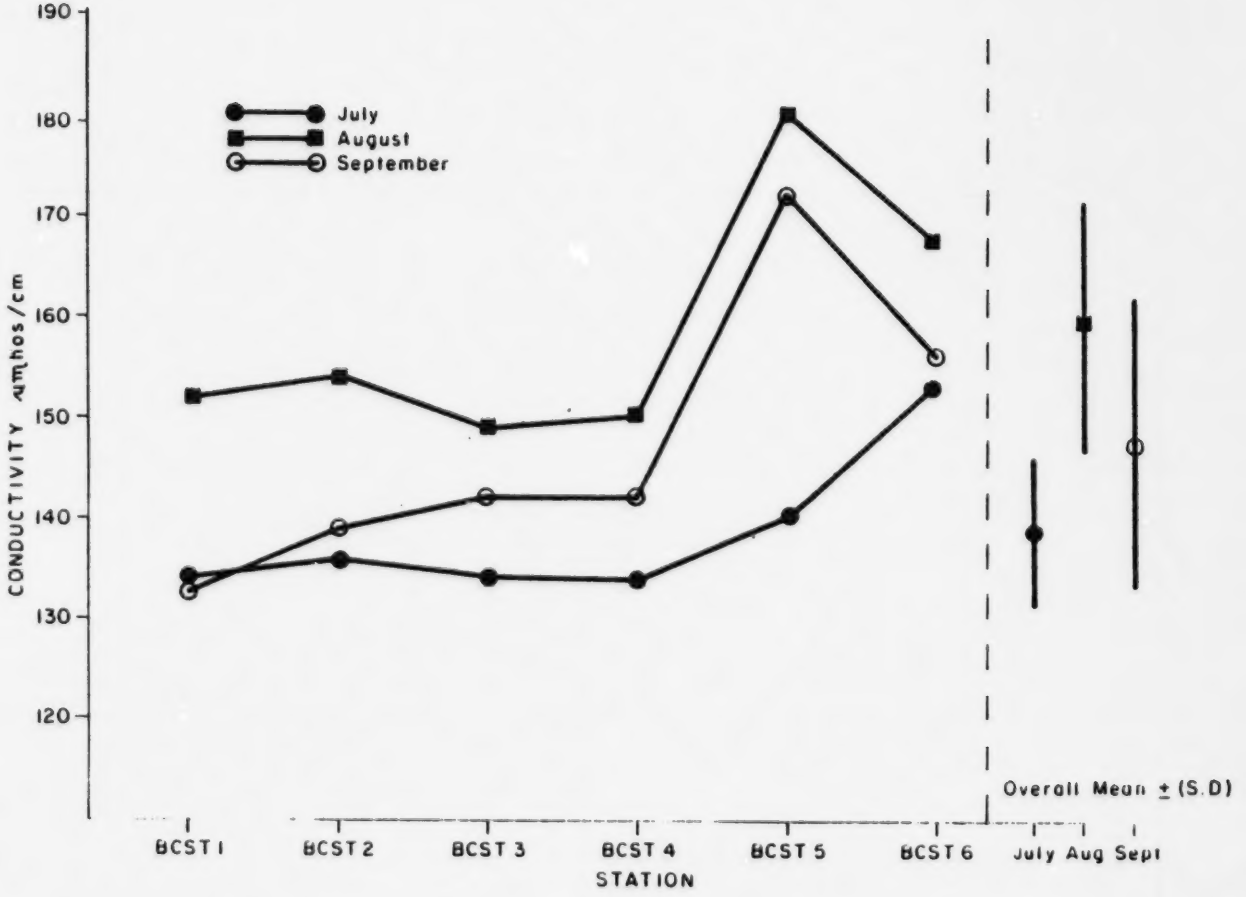


FIGURE 9 **CONDUCTIVITY VALUES (umhos/cm) MEASURED AT BIG CREEK MAINSTEM STATIONS, 1984.**

6. In September, the turbidity at Big Creek Station 6 was 0.30 F.T.U. Stoddart Creek had turbidity concentrations of 2.9 F.T.U. in both July and August and 0.10 F.T.U. in September.

Filterable residue (FR) or dissolved solids increased slightly from Big Creek Station 1 (108 mg/l) to Big Creek Station 6 (120 mg/l) in July and this trend was evident in August and September as well. Increases in concentration occurred at Big Creek Station 5. Mean filterable residues on Big Creek were elevated in August (125 $\pm$ 8.9 mg/l) as compared to September (120 $\pm$ 8.0 mg/l) and July (109 $\pm$ 5.9 mg/l).

ii) Other Parameters

Total alkalinity and hardness exhibited similar patters to conductivity in that spatial and temporal variations were apparent. Increased total alkalinity (Figure 10), total hardness and dissolved hardness occurred at Big Creek Station 5. All these parameters were elevated at each mainstem station during the August sampling period and were related to stream discharge levels at the time of sampling. Stoddart Creek had generally lower concentrations of the above parameters. Based on total hardness, Big Creek and Stoddart Creek were classified as medium hard water. Mean values for total alkalinity and hardness on the mainstem of Big Creek (Table 8) were comparable to results determined by Mathers et al (1981). Mean total hardness values were higher in July and September, 1984 (70.4 $\pm$ 7.4 mg/l and 73.2 $\pm$ 7.6 mg/l) than in July and September, 1980 (55.5 $\pm$ 21.2 mg/l and 59.4 $\pm$ 2.7 mg/l respectively).

Other parameters that exhibited spatial and temporal variations include total and dissolved sulphates (SO_4), dissolved nitrate (NO_3-N) and dissolved oxygen (DO). Generally, concentrations of these parameters increased at Big Creek Station 5, again indicating the influence of Seymour Creek on Big Creek. Most of these parameters were elevated during the August 14 sampling, with the exception of dissolved

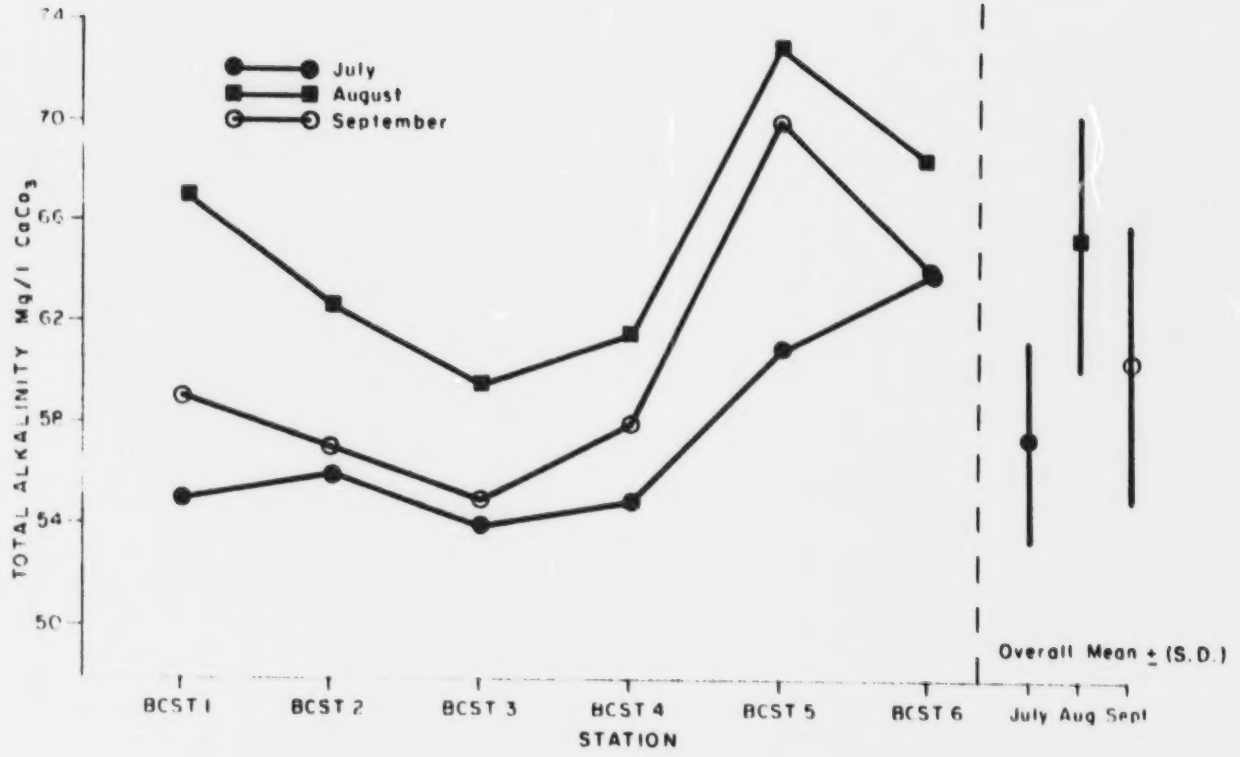


FIGURE 10 TOTAL ALKALINITY (mg/l as $CaCO_3$) MEASURED AT BIG CREEK MAINSTEM STATIONS 1984.

oxygen (DO) (Figure 11). Dissolved oxygen (DO) concentrations at all mainstem stations were highest during the September sampling period since at lower temperatures, water holds more oxygen.

On Stoddart Creek, total and dissolved sulphate (SO_4) concentrations were greater than on Big Creek probably resulting from a different bedrock formation. Total chloride (Cl), dissolved chloride (Cl), dissolved phosphate (PO_4-P) and dissolved nitrate (NO_3-N) were relatively constant between sample periods and varied little between the two creeks. Results of these parameters were comparable to Mathers et al (1981).

iii) Total Metals

Total metals concentrations for Big Creek and Stoddart Creek are contained in Volume II, Appendix II. Metal concentrations that occasionally exceeded recommended limits for drinking water and/or aquatic life (Appendix III, Table 4) are illustrated in Figure 12(a) and 12(b) and are summarized below:

Metal	Recommended Limit Exceeded
Aluminum (Al)	Aquatic life
Copper (Cu)	Aquatic life
Iron (Fe)	Drinking water and aquatic life
Mercury (Hg)	Drinking water and aquatic life
Manganese (Mn)	Drinking water
Zinc (Zn)	Aquatic life

It was difficult to determine if elevated total metal concentrations in the above group were a result of placer mining related activities, or geological or physical characteristics of the river drainage itself. However, this same group of metals were found to be significantly elevated downstream of an active placer operation on Little Gold Creek (Soroka and Mackenzie-Grieve, 1983).

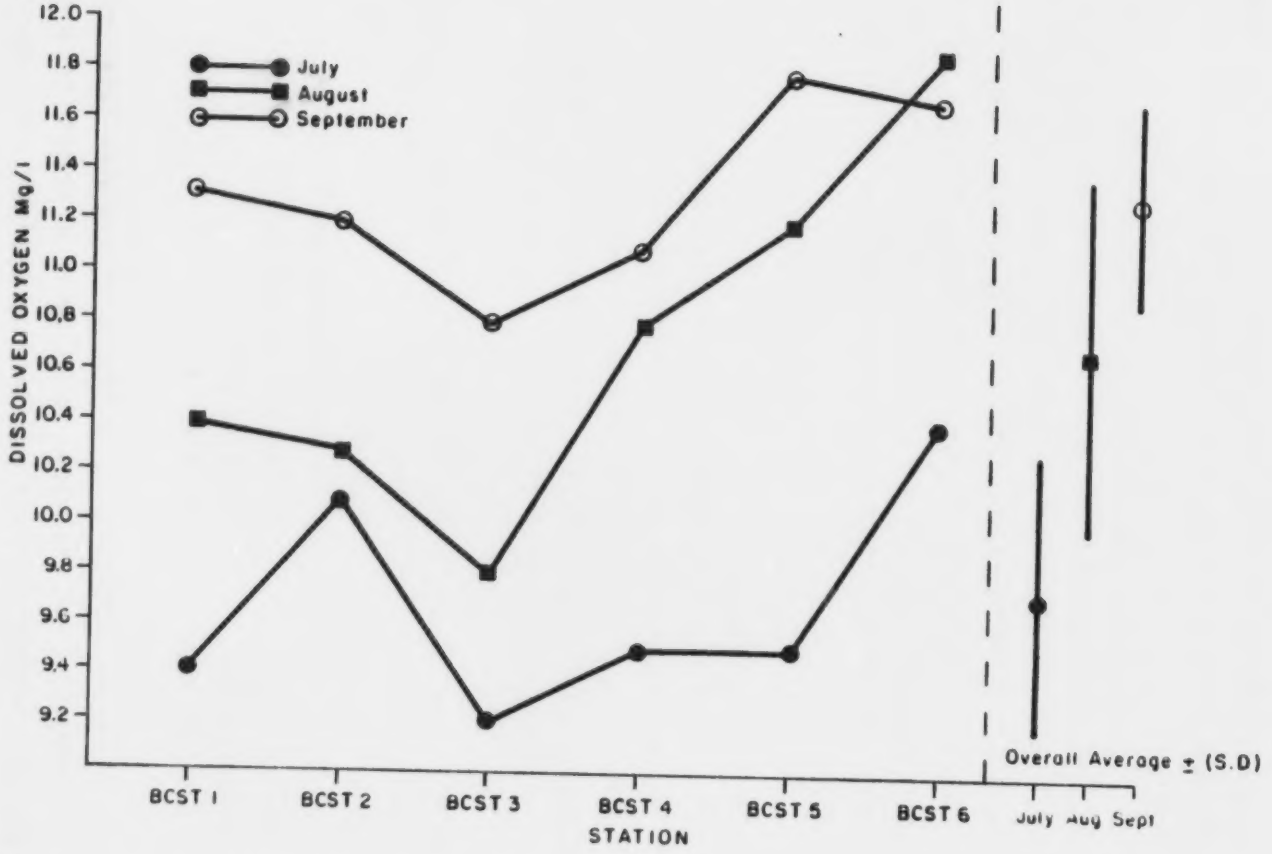


FIGURE 11 DISSOLVED OXYGEN CONCENTRATIONS (mg/l) MEASURED AT BIG CREEK MAINSTEM STATIONS, 1984

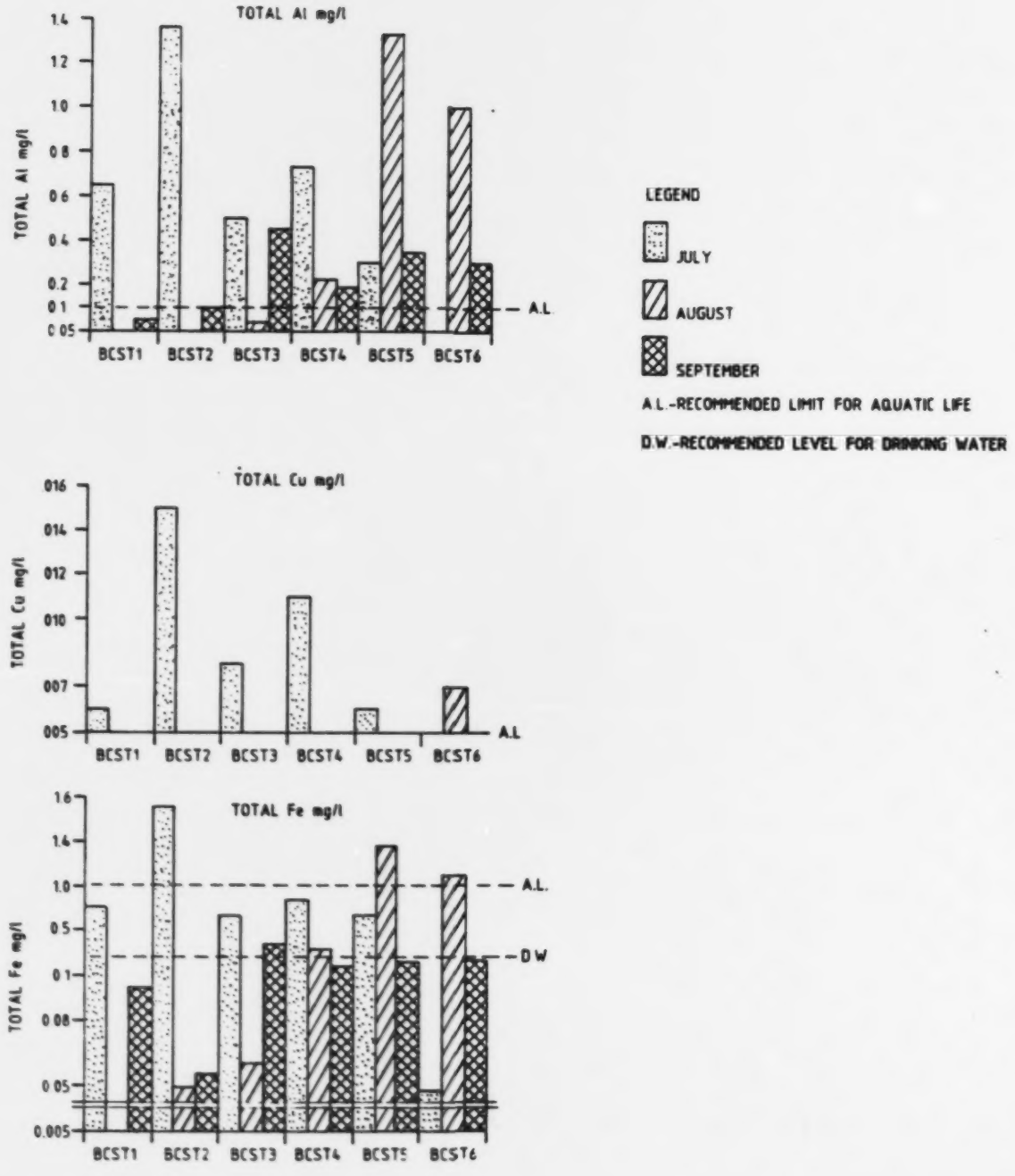


FIGURE 12a **TOTAL METALS OF ALUMINUM (Al), COPPER (Cu) and IRON (Fe) THAT EXCEEDED RECOMMENDED LEVELS FOR DRINKING WATER AND/OR LIMITS FOR AQUATIC LIFE.**

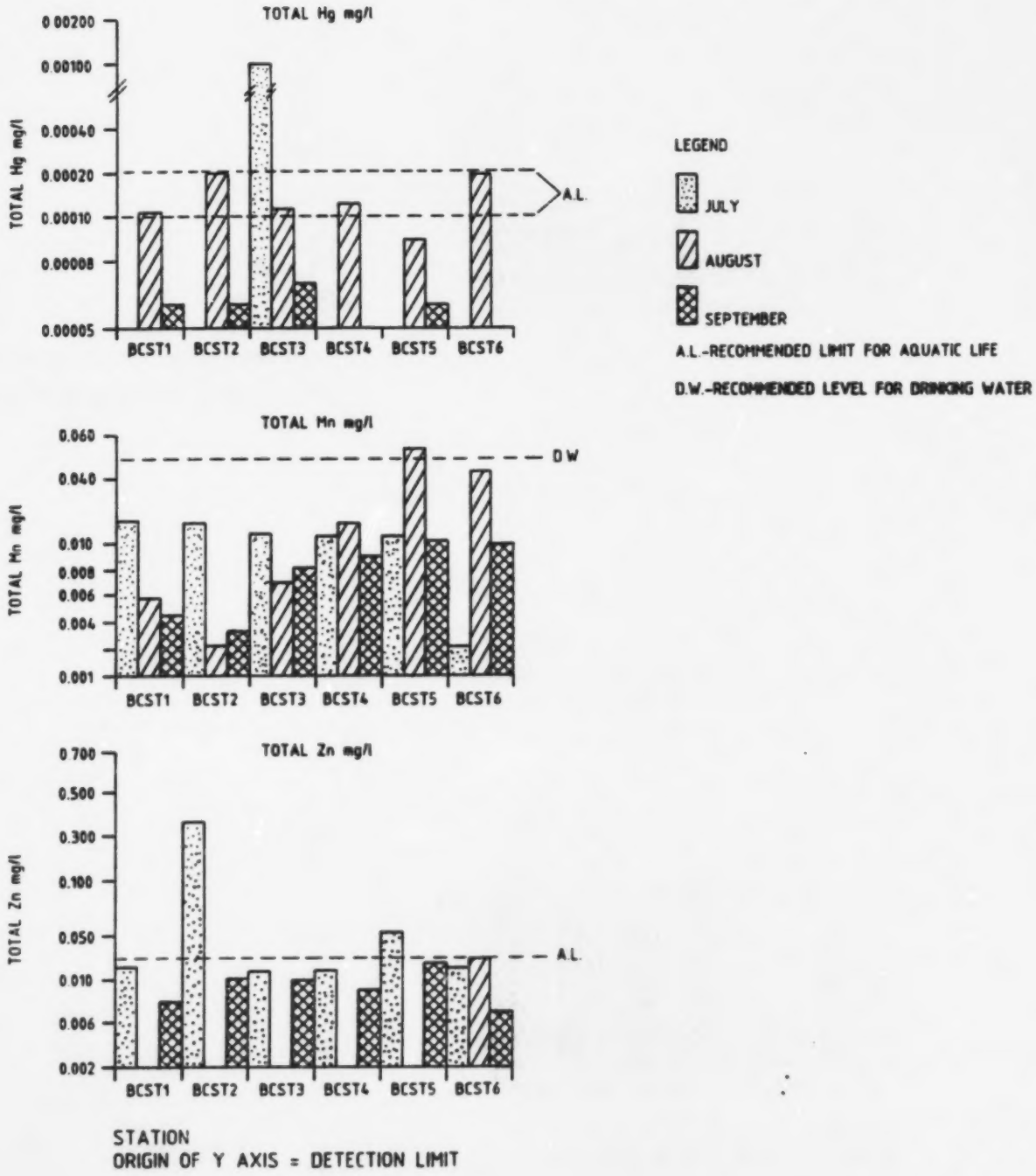


FIGURE 12b **TOTAL METALS OF MERCURY (Hg), MANGANESE (Mn) and ZINC (Zn) THAT EXCEEDED RECOMMENDED LEVELS FOR DRINKING WATER AND/OR AQUATIC LIFE.**

Total aluminum concentrations observation in this study ranged from 0.050 mg/l (detection limit) to 1.36 mg/l. Aluminum levels are common at 1.0 mg/l in surface waters due to the abundance of the element in the earth's crust (McNeely et al, 1979). Total aluminum concentrations were higher at the upper stations (Big Creek Station 1 to Big Creek Station 4) in July than in August or September. Aluminum concentrations were elevated in August at Big Creek Station 5 and Big Creek Station 6 (Figure 12a). Stoddart Creek had aluminum levels exceeding recommended limits for aquatic life in August (0.92 mg/l) and September (0.34 mg/l). The highest concentration of aluminum found by Burns (1980) was 0.236 mg/l at the Big Creek mainstem station located upstream of the Seymour Creek - Big Creek confluence.

Copper concentrations were generally below the detection limit of 0.0050 mg/l (recommended limit for aquatic life), however, copper was detected at all stations except Big Creek Station 6 in July and at Big Creek Station 6 during the August sampling.

Concentrations of total iron (Fe) at all stations ranged from 0.0050 mg/l (detection limit) to 1.56 mg/l. The recommended level for iron (Fe) in drinking water (0.30 mg/l) was established for aesthetic considerations (Health and Welfare Canada, 1978). Concentrations of total iron (Fe) were higher in the headwater stations in July than in August or September, although the downstream stations had higher iron (Fe) levels than the upper stations in August and September as compared to July.

Total mercury (Hg) levels exceeded recommended limits for aquatic life (0.00010 - 0.00020 mg/l) at most Big Creek stations (except Big Creek Station 5) and at the Stoddart Creek station in August. An elevated concentration of 0.0010 mg/l was recorded at Big Creek Station 3 in July (Figure 12b). Burns (1980) observed mercury (Hg) concentration below the detection limit (0.00020 mg/l) at all Big Creek stations.

A total manganese (Mn) level of 0.054 mg/l at Big Creek Station 5 in August was the only station that exceeded recommended limits for drinking water (0.050 mg/l). Stations with total zinc (Zn) concentrations that exceeded recommended limits for aquatic life (0.030 mg/l) included Big Creek Station 2 (0.365 mg/l) and Big Creek Station 5 (0.053 mg/l) during July.

Other total metals that demonstrated spatial or temporal variations, but were within the recommended levels for drinking water and aquatic life include; barium (Ba), boron (B), calcium (Ca), magnesium (Mg), silica (Si), sodium (Na), and strontium (Sr). Metal concentrations at or below detection limits include; antimony (Sb), arsenic (As), beryllium (Be), calcium (Ca), chromium (Cr), cobalt (Co), lead (Pb), molybdenum (Mo), nickel (Ni), selenium (Se), Tin (Sn), Titanium (Ti) and Vanadium (V).

The validity of the dissolved metals results were in question since dissolved metals results were greater than total metals in many instances. The filtering system or filteration procedure used in this study was not adequate. Separate sample collections should be considered for cadmium (Cd), lead (Pb) and selenium (Se) since the detection levels for these metals using ICAP analysis were above recommended limits for aquatic life.

Suspended Solids

Non-filterable residue (NFR) or suspended solids, can be defined as that particulate material suspended in water (sand, silt, clay, detritus) which is retained on a glass fiber filter after filtration. Suspended solids are a major concern with regards to placer mine effluent. The effects of suspended solids on aquatic habitats, fish and other aquatic populations has been well documented in papers by Cordone and Kelly (1961), Griffiths and Walton (1978), Langer (1980), Rosenberg and Snow (1975), and Pickral (1981). In general terms, the quantity and duration of sediment release relates directly to the severity of habitat destruction, which ultimately limits aquatic life.

Within the study area, suspended solid concentrations were monitored at all Big Creek mainstem stations and at the tributary stations. In addition, automatic water samplers monitored suspended solid concentrations hourly, over a 24 hour period at two locations on Big Creek and at the mouth of two placer tributary streams. Volume II, Appendices II, III and IV contains detailed water quality data for all these stations. Three samples were taken at all grab sample sites whenever possible to represent mean suspended solid values at the tributary and mainstem stations. Variations within replicate samples were common, however, more so in samples taken in placer streams.

Suspended solid concentrations in the upper reaches of Big Creek were near the detection limit, less than 5.0 mg/l, during all sample periods. Concentrations increased at Big Creek Station 3 and were further elevated at Big Creek Stations 4, 5 and 6 in both July and August (Figure 13). During the September field trip, suspended solid concentrations were near the detection limit at all stations. All placer mining operations in the study area were inactive during the September sampling. It is important to note that one placer mined stream empties into Big Creek upstream of Big Creek Station 3, and four placer streams flow into Big Creek between Stations 3 and 4.

Tributaries with no placer activity had suspended solid concentrations generally below 25 mg/l, although suspended solid concentrations as high as 50 mg/l were observed. These streams include the following:

TRIBUTARY	SUSPENDED SOLIDS (mg/l)*		
	JULY	AUGUST	SEPTEMBER
Tributary A	20.0	6.0	5.0
Burgess Creek	5.0	50.5	5.0
Magman Creek	5.0	9.0	5.0
Noname Creek**	7.5	6.0	39.5
Tributary B	-	-	21.5
Stoddart Creek**	18.7	40.7	11.7

* average of three replicate samples

** previous placer activity on these streams

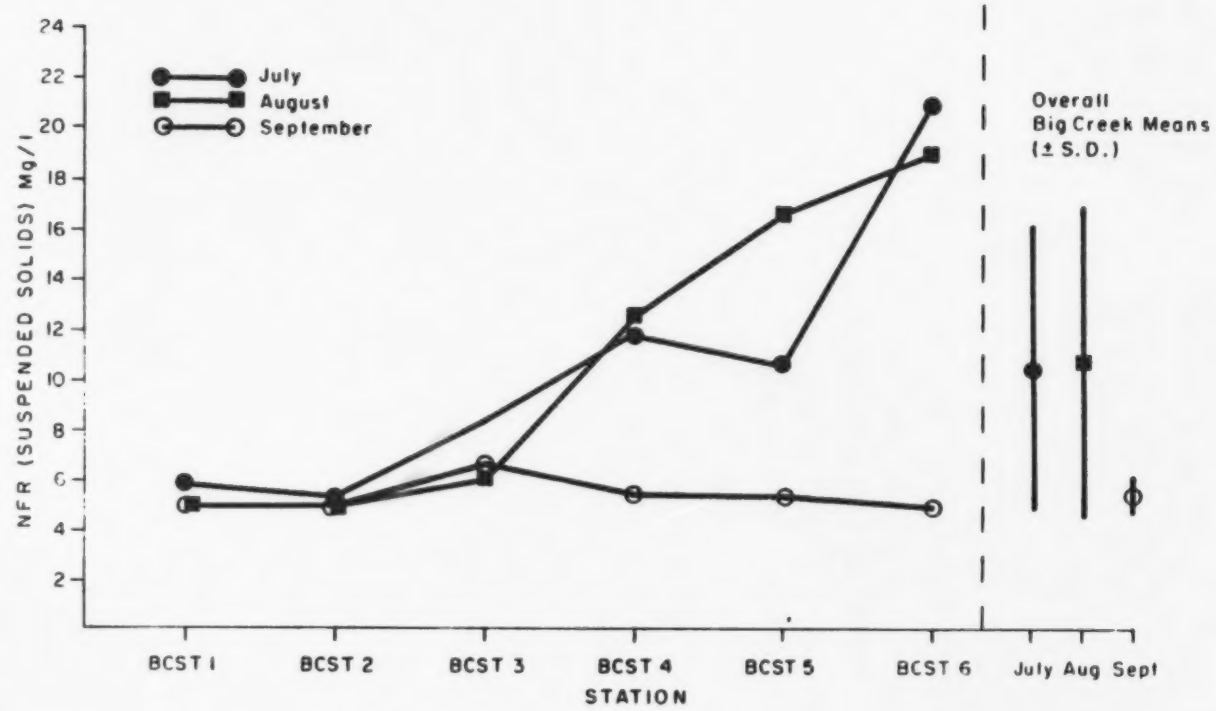


FIGURE 13 **SUSPENDED SOLIDS CONCENTRATIONS (mg/1) MEASURED AT BIG CREEK MAINSTEM STATIONS, 1984.**

Placer influenced tributaries had higher concentrations of suspended solids than non-placer tributaries with the degree of placer mining activity on that stream influencing sediment levels. Sampling effort was not directed at individual placer operations, so in most cases effluent discharge from a particular operation was not sampled in conjunction with the tributary outflow. However, effluent quality and downstream suspended solid levels from individual placer mine operations within the study area were significantly higher than sediment levels recorded at the tributary mouth. The following suspended solid concentrations were observed at the mouth of these tributaries.

TRIBUTARY	SUSPENDED SOLIDS (mg/l)*		
	JULY	AUGUST	SEPTEMBER
Boliden Creek	232	145	4290
Mechanic Creek	2180	87.0	38.0
Revenue Creek	21.8 (8.9)	93.6 (18.3)	95.3 (325)
Seymour Creek	8.3 (23.0)	23.0 (36.3)	7.8 (7.0)
Happy Creek	10.0	22.0	5.5
Tara Creek	14.0	57.5	11.5

* average of three replicate samples

(a) values in brackets represent mean suspended solid concentrations for a 24 hour period obtained from automatic sequential water samplers.

The automatic samplers (A.S.) were successful in detecting changes in suspended solid concentrations at the various sampler locations, although it was not always possible to coordinate sampling with sluicing activities on Revenue or Seymour Creeks. Figures 14, 15 and 16 illustrate suspended solid fluctuations within the 24 hour sample period at all automatic sampler stations.

On Seymour Creek (A.S. #1), a sudden pulse of suspended solids was measured in July, with sediment concentrations increasing from 5.0 mg/l to 47 mg/l within a 12 hour period (Figure 14). Sediment levels in Big Creek (A.S. #2; Big Creek Station 5) gradually increased

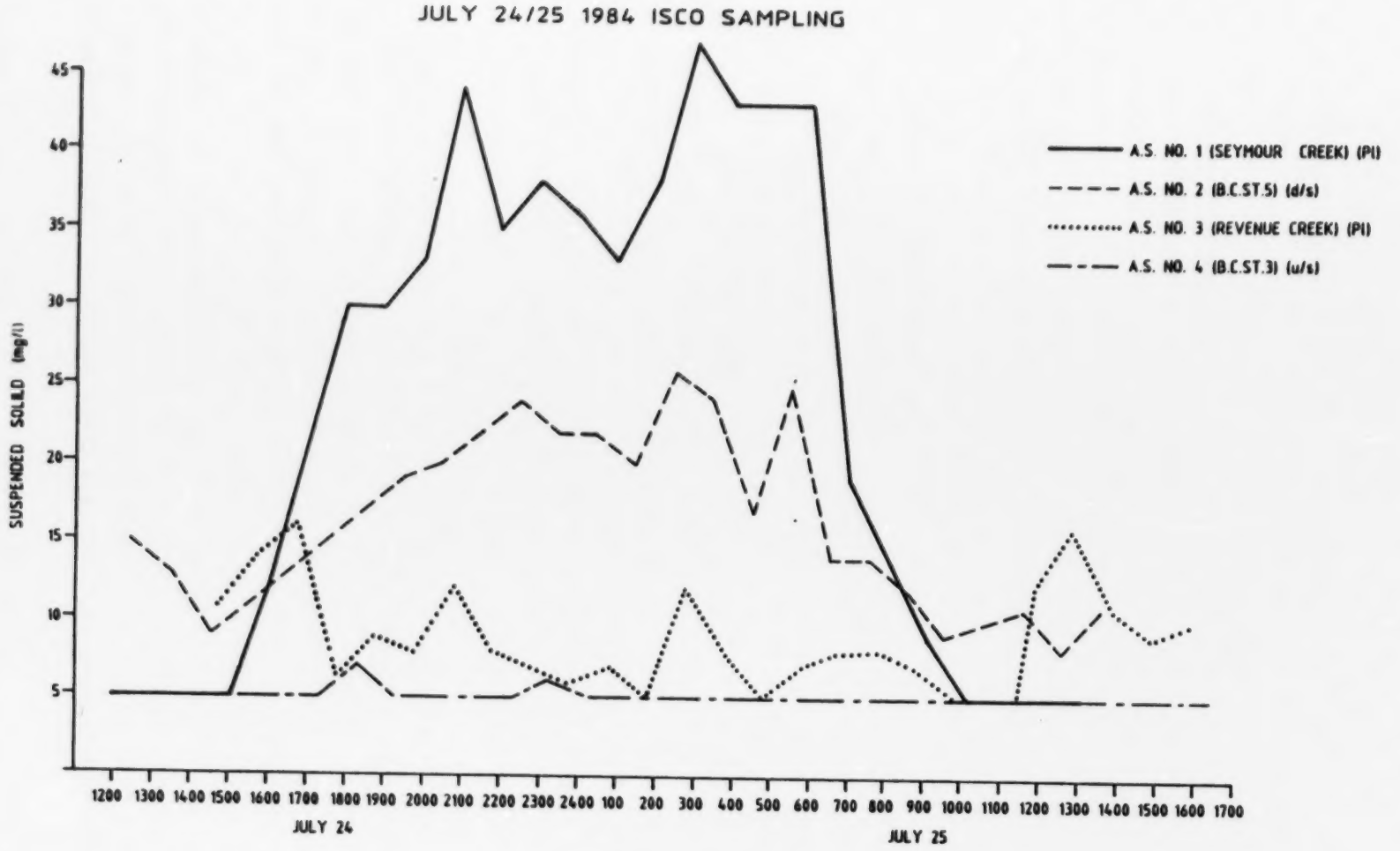


FIGURE 14 SUSPENDED SOLIDS CONCENTRAIONS AT AUTOMATIC WATER SAMPLER STATIONS, TAKEN ON JULY 24 AND 25, 1984.

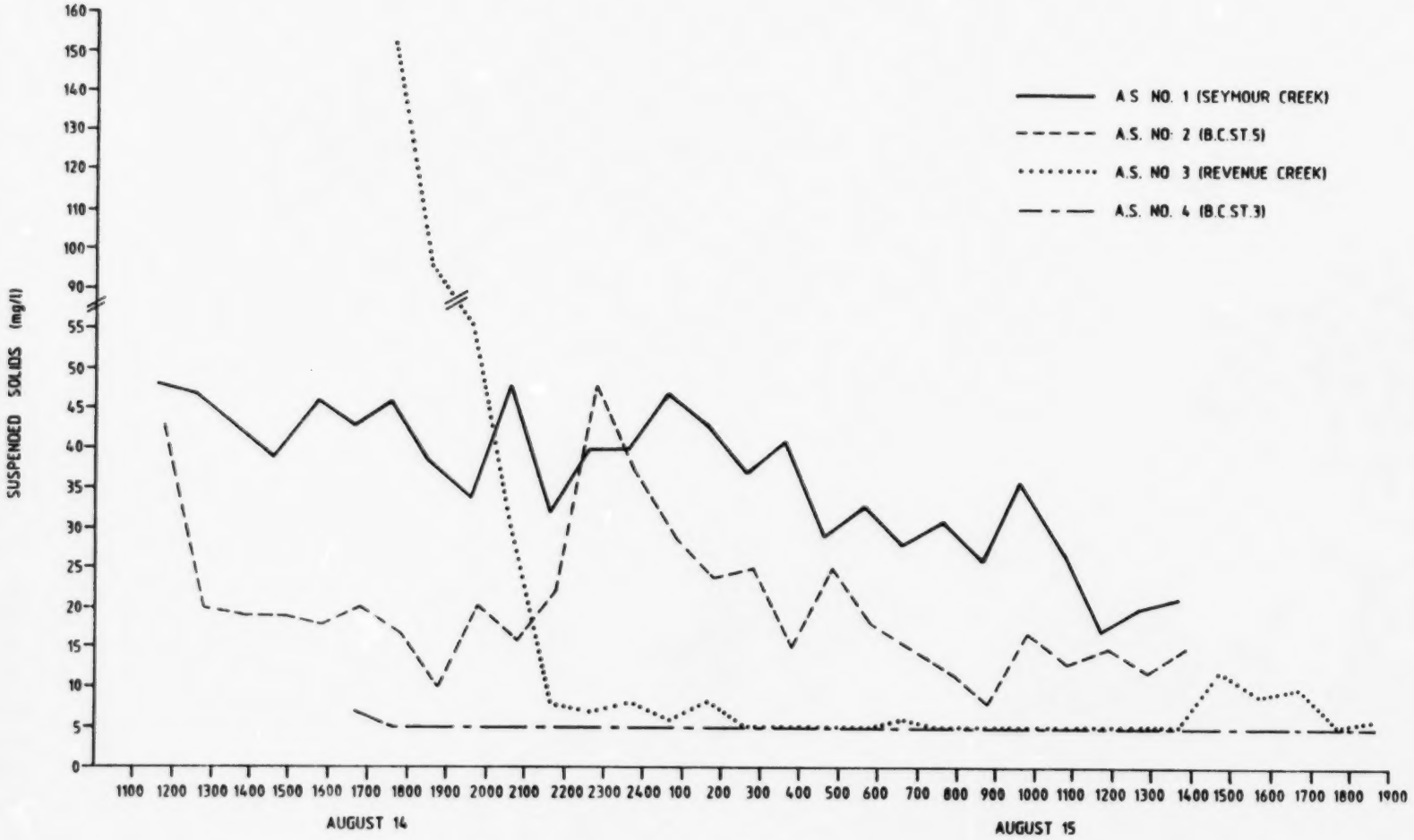


FIGURE 15 SUSPENDED SOLIDS CONCENTRATIONS AT AUTOMATIC WATER SAMPLER STATIONS TAKEN ON AUGUST 14 AND 15, 1984.

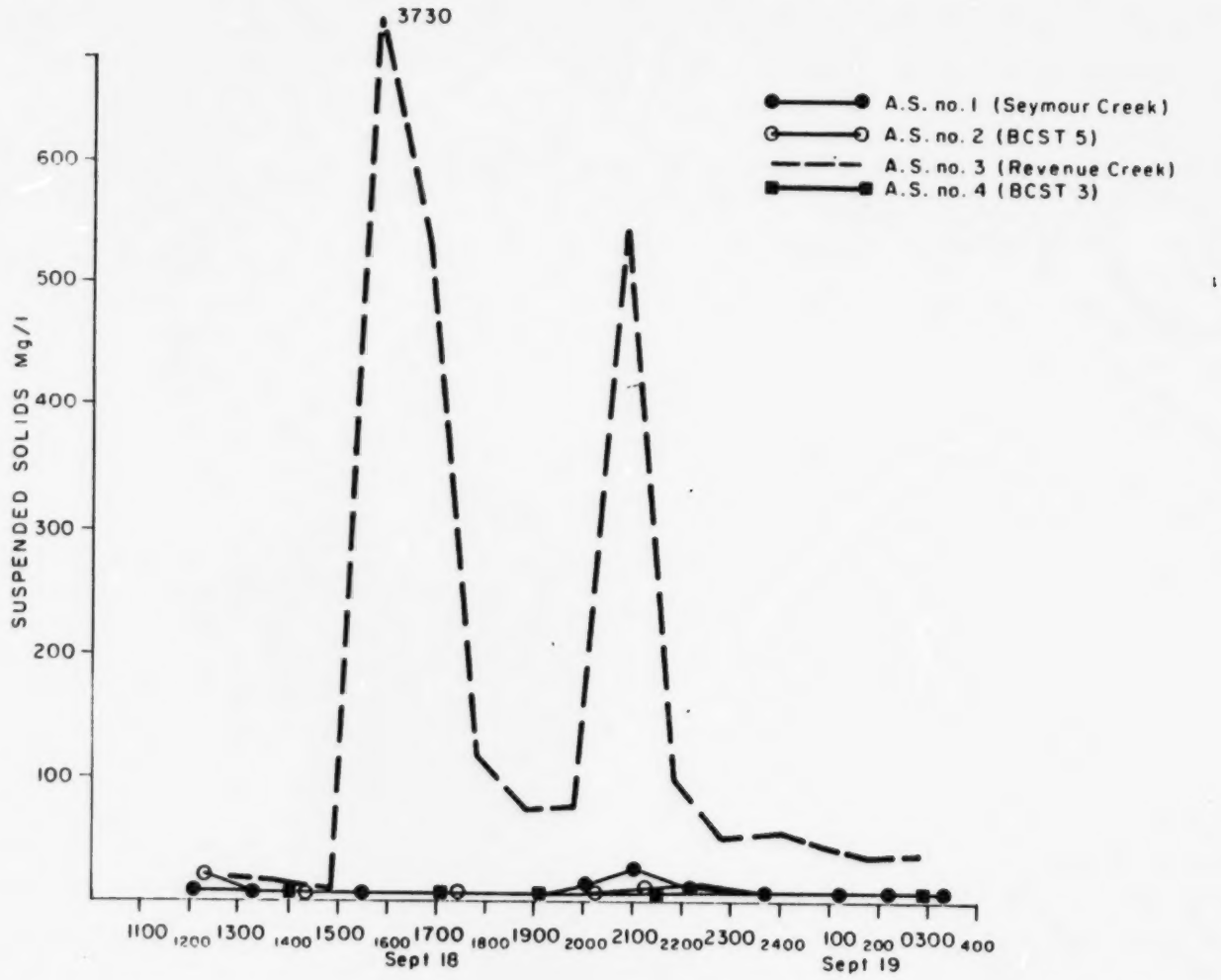


FIGURE 16 **SUSPENDED SOLIDS CONCENTRATIONS AT AUTOMATIC SAMPLER STATIONS, TAKEN SEPTEMBER 18 AND 19, 1984.**

from 9.0 mg/l to a maximum concentration of 26 mg/l within the same 12 hour period and subsequently declined reflecting the decrease in sediments from Seymour Creek. For comparitive purposes, samples taken on July 25 (0920 hours) at the placer operation on Seymour Creek, had suspended solid concentrations of 282 mg/l at the settling pond effluent and 47 mg/l 100m downstream of the settling facility. The automatic sampler on Seymour Creek was approximately 7.5 km downstream of this operation with a estimated five hour time lag in water movement existing between the operation and the automatic sampler.

Suspended solid concentrations in Big Creek (A.S. #2) paralleled closely to sediment levels in Seymour Creek, although elevated sediment levels from 16 mg/l (2045 hours; August 14) to 48 mg/l (2245 hours) at A.S. #2 may be attributable to sediments resulting from Revenue Creek (Figure 15). Suspended solid concentrations in Seymour Creek and Big Creek (A.S. #1 and A.S. #2) were generally below 10 mg/l during the September sampling (Figure 16) with no active placer mining occuring in the study area at that time.

Levels of suspended solids in Revenue Creek (A.S. #3) were quite erratic in July (maximum level of 16 mg/l) and it seems that the 24 hour sample period did not coincide with sluicing activities upstream of the sampler. Suspended solids reached a maximum concentration of 152 mg/l in August (Figure 15) and a maximum of 3730 mg/l in September (Figure 16). The results obtained from the automatic sampler on Revenue Creek in September are of interest since suspended solid concentrations on Revenue Creek were greater during the off season than during the active placer season. The elevated sediment levels on Revenue Creek in Septmeber were thought to result from the previous flushing of the settling facilities prior to winter abandonment, since the retaining walls of the settling ponds had been breached.

The automatic sampler stationed in the upper portion of Big Creek (A.S. #4 at Big Creek Station 3) had consistently low levels of suspended solids generally, less than 5.0 mg/l, during all sample periods. This was of importance since it demonstrates the baseline

level of suspended solids in the upper reaches of Big Creek. The distance between the automatic sampler stationed at Big Creek Station 5 was approximately 7 km. Within that 7 km, five placer streams empty into Big Creek, with Seymour Creek being the largest (Figure 5). In July and August, A.S. #4 (Big Creek Station 3) had mean sediment concentrations of 5.1 mg/l and 5.0 mg/l respectively, while A.S. #2 (Big Creek Station 5) had mean sediment concentrations of 16.3 mg/l and 20.6 mg/l for the same sampling period. This three to four fold increase in suspended solid concentrations in Big Creek was related to placer influence. With no placer mining activity on any of the tributaries; suspended solid concentrations in Big Creek were relatively uniform at both automatic sampler stations, and near the baseline level (5.0 mg/l).

The level of mining activity on placer tributaries had obvious consequences on sediment levels in Big Creek and it is expected that increased mining activity would further elevate suspended solids concentrations in Big Creek.

The automatic sampler also demonstrated the need for replicate sampling to occur within the stream and for sampling to occur over an interval of time. Large variations in sediment levels regularly occur on placer influenced streams within the study area.

In an attempt to perform a materials balance of sediment loading within the study area, Table 9, 10 and 11 were developed for each sample period. The study area was divided into reaches at mainstem Big Creek stations, and sediment loading in metric tons per day was calculated. The total measured sediment inputs within a particular reach was compared to the measured sediment load at the beginning of the next reach. This approach was used to see if a net gain or loss of sediments occured within a reach. It became apparent that the magnitude of the observed load differences were not great enough to overcome data measurement error. However, the tables are useful in showing the sediment load associated with each tributary. For example, Mechanic Creek had a measured sediment load of 2640 metric tons per day in July as compared to the total Big Creek sediment load at Big Creek Station 6

TABLE 9 SEDIMENT LOADS FOR BIG CREEK AND ASSOCIATED TRIBUTARIES

JULY, 1984

	FLOW		SUSPENDED SOLIDS	
	m^3/sec.	m^3/day	mg/l ± S.D.	tonnes/ day
REACH 1 (Initial Point)				
Big Creek St. 1	1.82	158000	5.8 ± 1.5	914
- Tributary A	0.040	3460	20.0 ± 21.8	69.1
- Burgess Creek	0.0060	518	5.0 ± 0.0	2.6
- Unnamed Creek	NIL	NIL	NIL	NIL
- Magman Creek	0.073	6310	5.0 ± 0.0	31.5
REACH 2				
Big Creek St. 2	1.89	163000	5.3 ± 0.5	866
- Noname Creek	0.014	1210	7.5 ± 2.1	9.1
- Unnamed Creek	NIL	NIL	NIL	NIL
- Mechanic Creek	0.014	1210	2180 ± 2690	2640
- Unnamed Creek	NIL	NIL	NIL	NIL
REACH 3				
Big Creek St. 3	1.75	151000	8.4 ± 3.3	1270
- Revenue Creek	0.189	16300	21.8 ± 10.5	356
- Bolliden Creek	0.00050	43.2	262 ± 36.8	11.3
- Happy Creek	0.0010	86.4	10.0 ± 2.8	0.90
- Tara Creek	0.0010	86.4	14.0 ± 7.1	1.2
- Unnamed Creek	NIL	NIL	NIL	NIL
- Tributary B	NIL	NIL	NIL	NIL
REACH 4				
Big Creek St. 4	2.33	202000	11.8 ± 3.3	2380
- Seymour Creek	0.86	74700	8.3 ± 1.6	620
REACH 5				
Big Creek St. 5	3.30	285000	10.6 ± 3.2	3020
- Unnamed Creek	NIL	NIL	NIL	NIL
- Stoddart Creek	0.310	26800	18.7 ± 1.5	501
REACH 6				
Big Creek St. 6	3.81	330000	20.8 ± 2.5	6850
(End Point)				

S.D. - Standard Deviation

TABLE 10 SEDIMENT LOADS FOR BIG CREEK AND ASSOCIATED TRIBUTARIES

AUGUST, 1984

	FLOW		SUSPENDED SOLIDS	
	m^3/sec.	m^3/day	mg/l ± S.D.	tonnes/ day
REACH 1				
(Initial Point)				
Big Creek St. 1	1.93	166000	5.0 ± 0.0	832
- Tributary A	0.018	1560	6.0 ± 1.7	9.3
- Burgess Creek	0.020	1730	50.5 ± 33.2	87.3
- Unnamed Creek	NIL	NIL	NIL	NIL
- Magman Creek	0.030	2590	9.0 ± 1.4	23.3
REACH 2				
Big Creek St. 2	2.13	184000	5.0 ± 0.0	921
- Noname Creek	0.026	2250	6.0 ± 0.0	13.5
- Unnamed Creek	NIL	NIL	NIL	NIL
- Mechanic Creek	0.033	2850	87.0 ± 1.4	248
- Unnamed Creek	NIL	NIL	NIL	NIL
REACH 3				
Big Creek St. 3	1.48	128000	6.0 ± 1.0	769
- Revenue Creek	0.273	23600	93.7 ± 98.0	2210
- Bolliden Creek	0.0080	691	145 ± 0.0	100
- Happy Creek	0.0040	346	22.0 ± 1.4	7.6
- Tara Creek	0.0020	173	57.5 ± 3.5	9.9
- Unnamed Creek	NIL	NIL	NIL	NIL
- Tributary B	NIL	NIL	NIL	NIL
REACH 4				
Big Creek St. 4	2.51	217000	12.5 ± 1.7	2710
- Seymour Creek	1.15	99600	23.0 ± 2.6	2290
REACH 5				
Big Creek St. 5	3.75	324000	16.7 ± 7.2	5400
- Unnamed Creek	NIL	NIL	NIL	NIL
- Stoddart Creek	0.639	55200	40.7 ± 3.1	2250
REACH 6				
Big Creek St. 6	4.27	369000	19.0 ± 2.2	7020
(End Point)				

S.D. - Standard Deviation

TABLE 11 SEDIMENT LOADS FOR BIG CREEK AND ASSOCIATED TRIBUTARIES

SEPTEMBER, 1984

	FLOW		SUSPENDED SOLIDS	
	m^3/sec.	m^3/day	mg/l ± S.D.	tonnes/day
REACH 1 (Initial Point)				
Big Creek St. 1	4.07	351000	5.0 ± 0.0	1760
- Tributary A	0.251	21700	5.0 ± 0.0	108
- Burgess Creek	0.029	2510	5.0 ± 0.0	12.5
- Unnamed Creek	NIL	NIL	NIL	NIL
- Magman Creek	0.085	7340	5.0 ± 0.0	36.7
REACH 2				
Big Creek St. 2	4.47	386000	5.0 ± 0.0	1930
- Noname Creek	0.063	5440	39.5 ± 2.1	215
- Unnamed Creek	NIL	NIL	NIL	NIL
- Mechanic Creek	0.070	648	38.0 ± 2.8	230
- Unnamed Creek	NIL	NIL	NIL	NIL
REACH 3				
Big Creek St. 3	4.51	390000	6.7 ± 4.5	2610
- Revenue Creek	0.0080	691	95.3 ± 100.8	65.9
- Bolden Creek	0.0050	432	4290 ± 56.6	1850
- Happy Creek	0.016	1380	5.5 ± 0.7	7.6
- Tara Creek	0.0040	346	11.5 ± 2.1	4.0
- Unnamed Creek	NIL	NIL	NIL	NIL
- Tributary B	0.092	7950	21.5 ± 0.7	171
REACH 4				
Big Creek St. 4	4.98	430000	5.3 ± 0.5	2280
- Seymour Creek	1.84	159000	7.8 ± 2.0	1240
REACH 5				
Big Creek St. 5	6.84	591000	5.3 ± 0.5	3130
- Unnamed Creek	NIL	NIL	NIL	NIL
- Stoddart Creek	0.634	54800	11.7 ± 1.2	641
REACH 6				
Big Creek St. 6	6.83	590000	5.0 ± 0.0	2950
(End Point)				

S.D. - Standard Deviation

of 6850 metric tons per day. This particular sediment load in Mechanic Creek was almost as great as the total Big Creek sediment load at Big Creek Station 6 in September (2950 metric tons per day).

3.1.4 Summary and Recommendations

In general, water quality at all Big Creek mainstem stations and the Stoddart Creek station was similar to water quality results reported by Mathers et al (1981) and Burns (1980).

Certain total metals concentrations (Al, Cu, Fe, Hg, Mn and Zn) occasionally exceeded recommended level for drinking water and/or recommended limits for aquatic life.

Spatial variation on the mainstem of Big Creek was noted for most water quality parameters. The general trend was an increase in the concentration moving downstream from Big Creek Stations 1 to 6, with increases occuring at Big Creek Stations 3 or 5. It is noteworthy that two placer operations on Mechanic Creek flow into Big Creek up-stream of Big Creek Station 3, while five placer tributaries, with a total of five active operations, flow into Big Creek between Big Creek Stations 3 and 5.

Seymour Creek(largest tributary to Big Creek) influences water quality parameters upon emptying into Big Creek below Big Creek Station 4.

Some degree of temporal variation was noted in water quality parameters between the sampling periods. Most water quality parameters increased in concentrations during the August sampling period as compared to results from July and September.

Suspended solids concentrations in Big Creek never exceeded 50 mg/l at the most downstream station (Big Creek Station 6). Samples taken with the automatic water samplers on Revenue and Seymour Creeks showed large variations in suspended solid concentrations during the 24 hour sampling periods, reflecting the effect of placer effluent discharge. Slight variations in suspended solid concentrations were detected at the automatic sampler situated at Big Creek Station 5, indicated the influence of Seymour Creek. Suspended solid concentrations at Big Creek Station 3 remained near the detection limit of 5.0

mg/l. Increases in suspended solid concentrations at Big Creek Stations 5 and 6 were attributable to the influence of placer streams. The highest levels of suspended solids were recorded at the effluent discharge of placer mining operations.

It is recommended that:

A. The continued monitoring of water quality on the mainstem of Big Creek should be encouraged. System linkages need to be further examined especially the movement of sediments and metals from point of discharge, through the tributary into the mainstem. The following are additional requirements.

1. Tributaries:

Detailed water chemistry should be monitored on each placer tributary, especially in the following locations;

- the receiving water upstream of the placer operations,
- settling pond effluent,
- receiving water downstream of the effluent discharge, and
- at the tributary mouth.

At present, the specific source of metal contamination in the mainstem of Big Creek is unclear. Sampling in the above locations would assist in following the movement of metals through the tributary and into the mainstem.

In addition, the movement of sediments from point of discharge through the tributary into the mainstem is unclear. Suspended solids should be monitored in the above locations, using automatic water samplers stationed downstream of the effluent discharge and at the tributary mouth. Sampling should be coordinated with sluicing activities to follow the pulse of sediments through the system.

A comparison between natural and placer stream sediment transport should be initiated since the capacity of a particular stream to cleanse itself of a sediment load is unclear.

2. Mainstem Big Creek:

Continued monitoring of water quality in conjunction with

detailed tributary water quality to detect specific influence of tributaries on mainstem water quality. Big Creek Station 2 could be eliminated.

3. Sampling Frequency:

   Sampling should occur in all seasons if possible to detect temporal variations in water quality. Spring sampling to determine maximum sediment loading and scouring during freshet, and fall sampling to delineate seasonal abandonment effect.

4. Replicate Sampling:

   Continued use of automatic sequential water samplers to demonstrate fluctuations in sediment loading. The use of a single grab water sample to present suspended solids concentrations is inadequate. A minimum of three replicate samples transecting the stream width would better represent sediment levels. This is of particular importance when sampling placer mining effluent quality.

5. Concurrent Information:

   Before an adequate assessment of the influence a particular placer stream has on the mainstem drainage, it is imperative that concurrent information on each placer operation is available. It is important to know when an operation is sluicing and the amount of materials sluiced, to be able to follow a particular pulse of sediment load from effluent discharge to the mainstem.

B. The present study design, with the above modifications, would be a valuable management tool in the evaluation of other drainages where active placer mining occurs.

3.2 Fish Inventory

3.2.1 Introduction

An inventory was made of Big Creek and north flowing tributaries from Magman to Stoddart Creek inclusive during August 24 to 31 and on September 8, 1984. This inventory was carried out by the Department of Fisheries & Oceans Habitat Management, as a result of concerns by placer miners regarding the classifications given to these streams. The classification system used in the Yukon (ICPM, 1983) affords the greatest protection to streams with spawning salmon. In declining order of protection are rearing salmon fry habitat, arctic grayling spawning and rearing habitat and finally, migration and feeding habitat for adult fish of all species. A further classification is given to streams that were extensively effected by historical placer mining. This inventory was carried out incidently to the Big Creek project, but is included in this report as it is within the area studied by the project.

The inventory was to determine:

1. whether chinook salmon were spawning in Big Creek, and, if so, where, and;
2. whether the classifications given to the streams in the area concerned were valid.

Fish utilization of northern streams is a dynamic process. The harsh climatic conditions allow much habitat to be used only seasonally. Stream feeding fish must derive much of all annual nutrition during a short open water season, and are aggressive feeders. This is associated with spring migrations into, and to the upper limits of, tributary streams. Grayling sub-adults and adults exhibit this behavior, as do chinook salmon fry. Grayling fry move towards over-wintering areas, which are generally located downstream.

Mid to late August was chosen for this inventory to ensure full dispersal of fish into the tributaries. This was biased toward the presence of chinook fry rather than spawning grayling. A chinook

fry rearing habitat is given a higher degree of protection than grayling spawning habitat, this was considered the best utilization of limited resources.

On August 25, unseasonally cold weather, combined with snow, resulted in an immediate drop in the temperature of Big Creek from 9°C to 6°C. Temperatures continued to drop, reaching as low as 2°C (Seymour Creek, August 29). Although this may have affected the inventory to some extent, enough fish were captured to fulfill the objectives of the inventory.

3.2.2 Methods

A helicopter reconnaisance of the areas to be inventoried was flown on August 24, 1984. This was to determine means of access, appropriate sampling methods, equipment, and the amount of time required to assess the area. Big Creek was flown from Magman Creek downstream to a point approximately 16km (10 miles) downstream of Stoddart Creek in search of spawning chinook salmon.

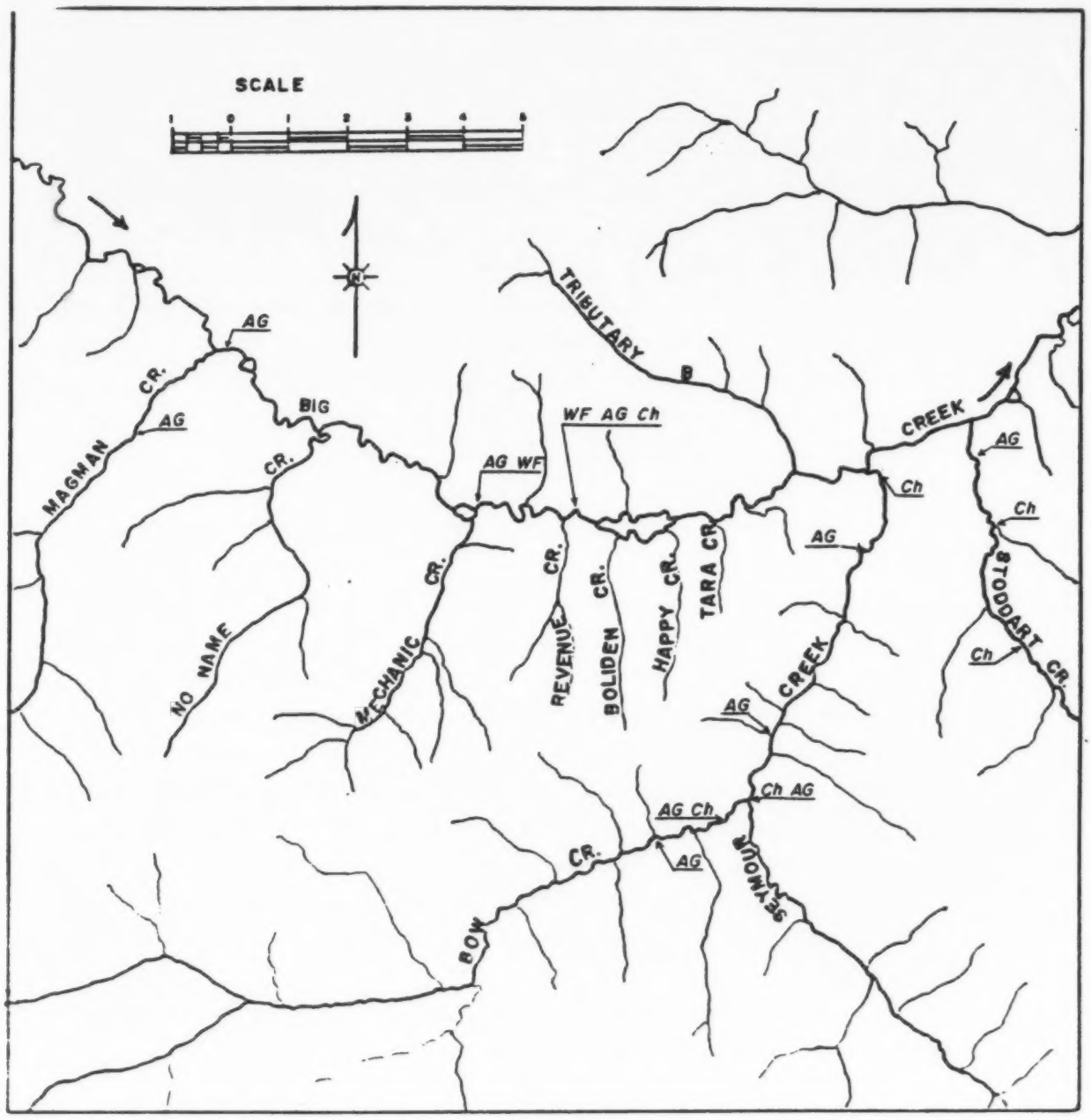
Sampling methods varied widely with stream conditions. Most sampling was conducted with a 10m by 2m beach seine net or a Smith-Root MK VII electrofisher. Stick seines and angling were also used where conditions permitted. Sampling was only to confirm the presence of indicator species and life stages at the particular site, and not to determine total numbers of fish present.

3.2.3 Results and Discussion

Figure 17 and Volume II, Appendix V, Table 1 indicates the results of the inventory. Discussion by species follows.

Chinook Salmon (Oncorhynchus tshawytscha)

No spawning adults were observed on either the August 24 nor a subsequent flight on September 8. Viewing conditions were good, with arctic grayling and round whitefish visible in riffle areas. In all



AG = Arctic Grayling Ch = Chinook Salmon WF = Round Whitefish

FIGURE 17 RESULTS OF FISHERIES INVENTORY, 1984.

probability Big Creek is utilized by an early segment of the chinook spawning run. Supporting this was the sighting on August 14/84, of a male Chinook in an advanced stage of maturity at the confluence of Seymour and Big Creeks.

A total of 35 chinook salmon fry were captured. Of these, 20 were captured on August 24 over a very short section of Big Creek during equipment testing. A much longer section of Big Creek including the area noted above was sampled after the storm of August 25, during which only one chinook fry was captured. Chinook fry migrations have been poorly addressed in Yukon streams, and the sudden disappearance noted above may be the result of a downstream migration induced by falling stream temperatures.

Chinook fry were observed in Seymour Creek to the confluence with Bow Creek, and at a site approximately 500 meters up Bow Creek. Above the confluence of these streams, the physical characteristics of the Bow remain essentially unchanged for approximately 6 kilometers (to the confluence with the first major tributary from the west), and this should also be considered chinook rearing habitat. Seymour Creek rapidly increases in gradient, and was in the process of being placer mined. Sampling was not carried out.

Chinook fry were collected in Stoddart Creek to the upper limit of what was considered chinook rearing habitat, and in mainstem Big Creek.

No fry were found in the other tributaries investigated. Magman Creek appeared to have marginal rearing habitat.

Arctic Grayling (Thymallus arcticus)

Adult and subadult arctic grayling were observed in almost all of the sampling sites, save in upper Stoddart Creek. Seventy-eight (78) were sampled for length and scales. Those sampled represented only a fraction of the fish seen.

Grayling fry were located in only one location, in the mainstem of Big Creek near the mouth of Revenue Creek. The significance of this is not clear. Investigations in Central Alaskan streams

have shown a downstream migration of grayling fry during July and August which could explain the lack of fry. The bulk of grayling spawning might also take place in Big Creek downstream of Stoddart Creek. Further investigation will be necessary to determine this.

Other Species

Only round whitefish (Prosopium cylindraceum) and slimy sculpin (Cottus cognatus) were encountered. The former were found in the mainstem of Big Creek, and the latter were ubiquitous.

3.2.4 Recommendations

The question of grayling spawning and rearing was not addressed in this inventory. It is recommended that this be rectified by sampling session earlier in the season, preferably mid July.

Big Creek could be used as the site of studies to address the following information needs:

1. Response of grayling at various life stages increased to suspended sediments in natural stream situations.
2. Changes in substrate as a result of placer mining, both degree and extent.
3. Changes in stream morphology resulting from additional bed load.
4. Rehabilitation of streams, both in the area mined and downstream.
5. Changes in stream side and adjacent vegetation, both in the area mined and downstream.

The following information needs could also be addressed in the Big Creek drainage. However, they could be carried out in a more cost effective manner in less isolated streams.

1. Chinook salmon spawning in minor watersheds not buffered by headwater lakes.
2. Upstream migration of chinook salmon fry, both for extent and for timing.
3. Natural history studies of arctic grayling in minor watersheds not buffered by headwater lakes. These could include spawning, rearing, feeding, migration timing, etc.

3.3 Benthic Invertebrate and Sediment Characteristics

3.3.1 Introduction

Benthic invertebrates and sediment characteristics information for the Environmental Overview of Big Creek, Yukon, as related to Placer Mining, was gathered by Environment Canada, Environmental Protection Service, Yukon Branch.

The use of the benthic invertebrates as a stream quality indicator is guided by certain biological considerations. The invertebrates because of relatively low mobility, reflect the conditions of a particular stream location. The variability of physical and chemical conditions over time can be integrated by the benthic community and give the observer an idea of the environmental state in which the invertebrates exist.

Sediment characteristics, including particle size composition and metals content, can be important factors influencing aquatic life in a stream. Particle size composition of stream bed sediments is a major factor determining the suitability of the substrate for certain groups of benthic invertebrates. The metals content of sediments directly influences water quality and may be beneficial or detrimental to stream inhabitants depending on concentrations present. Information concerning these topics in association with water quality and fisheries information can contribute to a better understanding of the stream ecology.

3.3.2 Methods

Benthic Invertebrates

Bottom fauna were collected using a Surber Sampler (900 cm^2) with a mesh size of 0.363 mm. Five replicate samples were taken at each of the seven stations on July 24, August 14 and September 18, 1984 at the same time as sediment samples were collected. Bottom fauna collection, preservation and identification methods are given in Appendix III, Table 2.

Taxonomic features. The invertebrate community was analysed for total numbers and densities, as well as percent composition by the taxonomic groups.

Diversity/Evenness Indices. Diversity indices were calculated from the bottom fauna data using the Shannon-Weiner diversity index described by Pielou (1975) and modified as follows:

$$\text{Species Diversity } (H') = -\sum_{i=1}^{g} (P_i \log_{10} P_i)$$

where $P_i = n_i/N$

n_i = total number of individuals in the i^{th} genus

N = total number of individuals identified to genus level

g = total number of genera

The use of individuals identified to genus level instead of to species level results in slightly lower diversity index (H') values (Hughes, 1978). Individuals that were not identified to genus or species level, were not included in the species diversity calculation but are listed in Volume II, Appendix VI, Table 2.

The diversity of the benthic invertebrate community depends on the number of species and the evenness with which the individuals are apportioned among them. The method of measuring evenness is described by Pielou (1975) and is given by the formula:

$$\text{EVENNESS } J' = \frac{H'}{\log g}$$

where H' = the species diversity

g = the number of genera

Community Index. The benthic communities were also analysed using the Percent similarity index (Psc) as the community index, comparing each station to other stations using the formula as described by Brock (1977):

$$Psc = 100 - 0.5 \sum_{k} |a-b|$$

Where a and b are for a given species, percentage of the total Sample A and B which that species represents.

Streambed Sediments

Sediment samples were collected simultaneously with other field sampling for benthic invertebrates. Three replicate samples were collected at each station from just below the low water mark, to a water depth of up to 0.5 metres at each station. A description of sediment collection, preparation and analysis methods is given in Appendix III Table 3. All sediment samples were shipped by air for analysis at Laboratory Services, Environmental Protection Service, West Vancouver.

Statistical analyses included the calculation of the arithmetic mean (x), standard deviation (S.D.), coefficient of variation (V*) corrected for small sample bias, and confidence limits for the statistics' differences using the Student's t-distribution (Sokal, 1981).

Sediment Particle Size. Each of the three replicates sampled on July 24, August 14 and September 18, 1984 at each station, was analysed for the following seven class sizes;

Particle Size	Common Name
>2.0mm	Gravel
>1.0-<2.0mm	Very coarse sand
>0.5-<1.0mm	Coarse sand
>0.25-<0.5mm	Medium sand
>0.15-<0.25mm	Fine sand
>0.063-<0.15mm	Very fine sand
<0.063mm	Silt and clay

Visual assessment of large substrate particles was carried out on site. The percentage composition of the streambed at each station was assessed. The particles were classified in three ranges;

Particle Size	Common Name
> 64mm	Cobbles and Boulders
2-64mm	Pebbles and Gravel
< 2mm	Fine particles

Sediment Metals. Each of the three replicate sediment samples collected at each station on July 24, August 14 and September 18, 1984, analysed the fraction of sediment with a particle size of less than 0.15 mm, for the following leachable metals:

Aluminum (Al)	Iron (Fe)	Silicon (Si)
Arsenic (As)	Lead (Pb)	Silver (Ag)
Barium (Ba)	Magnesium (Mg)	Sodium (Na)
Beryllium (Be)	Manganese (Mn)	Strontium (Sr)
Cadmium (Cd)	Mercury (Hg)	Tin (Sn)
Calcium (Ca)	Molybdenum (Mo)	Titanium (Ti)
Chromium (Cr)	Nickel (Ni)	Vanadium (V)
Cobalt (Co)	Phosphorus (P)	Zinc (Zn)
Copper (Cu)	Potassium (K)	

3.3.3 Results & Discussion

Benthic Invertebrates

Benthic invertebrates have been used as water quality indicators in placer studies in Yukon (Burns, 1980), (Mathers et al, 1981), (Soroka, 1983), (Weagle, 1980), Alaska (Van Nieuwenhuyse, 1984) and Northern British Columbia (Taekema, 1983). Other studies of general effects of sedimentation on biota are given in Gammon (1970), Griffiths and Walton (1978), Hynes (1973), Luedtke and Brusven (1976), Rosenberg and Snow (1975), Sherk (1971), Wilzbach (1983).

The effects of sediment releases on stream invertebrate populations are two fold, indirect and direct. The indirect effect include the fact that many invertebrates are dependent on periphyton (organisms attached to the sediments) for food. The scouring action of suspended solids affect the periphyton and also decreases the light transmittance in the stream which in turn reduces the productivity (Van Nieuwenhuyse, 1984). A direct effect is that sediments may cover deposits of leaves and other organic detritus limiting an important food source for a wide range of invertebrates (Hynes, 1972). Other direct effects are; increased drift response, embedding of the benthic fauna, decrease of suitable habitat, and reduction of intergravel flow and oxygenated water.

The data for the benthic invertebrates is listed in Volume 2, Appendix VI Tables 1 and 2.

Taxonomic Features. Sampling at the seven stations during the three survey periods yielded a total of 6,865 organisms, comprising 77 taxa. Densities of invertebrate organisms, ranged between lows of 30 and highs of 151 organisms per square foot (0.090 m^2).

These densities are from 7 to 21 times greater than a previous study in 1980 (Mathers et al, 1981) in the same vicinity (Table 12). In July and September the upstream stations show higher densities than the downstream stations. In August, Station 3 and Station 5 had higher densities than the control Stations 1 and 2. This can be partially attributed to Cricotopus sp. being present in greater numbers at Stations 3 and 5, and Cinygmula sp. present at Station 3. The seasonal succession may explain this sudden increase. Rosenberg and Wiens (1978) indicated seasonal variation in drift response of macroinvertebrates to sediment addition, the effect being greater in September than August in the Harris River, Northwest Territories.

The composition of the benthic fauna changes throughout the seasons as shown in Table 13. The numbers of organisms per taxa reveals a high proportion of Ephemeroptera and Diptera. The Ephemeroptera and Trichoptera become more abundant in September while Diptera becomes less predominant. Between July and September, the amount

TABLE 12 TOTAL DENSITY OF BENTHIC INVERTEBRATES PER FOOT SQUARE (0.090 m^2)

STATION	SAMPLING PERIOD				
	JULY		AUGUST	SEPTEMBER	
1	115	6.0[a]	67.6	151	20.3[a]
2	74.8		62.2	69.2	
3	48.2		150	61.0	
4	65.4	2.6[a]	43.4	54.4	4.0[a]
5	41.8		73.8	54.6	
6	46.8		37.8	46.6	
Stoddart Creek	38.6		41.4	29.6	

(a) Data modified from Mathers et al (1981).

TABLE 13 MEAN NUMBER OF BENTHIC INVERTEBRATES BY TAXA (N=5) PER SQUARE FOOT (0.090 m) AND PERCENT COMPOSITION OF SAMPLE (IN BRACKETS)

TAXA	STN	SAMPLING PERIOD									
		JULY '84		JULY[a] '80		AUGUST '84		SEPT. '84		SEPT[a] '80	
		$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%
Ephemerop-	1	38.2	(33.3)	4.3	(81)	22.8	(33.7)	132	(87.0)	10	(49)
tera	2	34.2	(45.7)			20.8	(33.4)	31.6	(45.7)		
	3	22.0	(45.6)			58.4	(39.0)	46.8	(76.7)		
	4	36.2	(55.4)	1.0	(60)	27.4	(64.1)	40.8	(75.0)	0.7	(17)
	5	26.2	(62.7)			33.0	(44.7)	31.6	(57.9)		
	6	16.0	(34.2)			2.8	(7.4)	21.2	(45.5)		
	Stoddart	8.4	(21.8)			21.0	(50.7)	14.6	(49.3)		
Plecoptera	1	2.4	(2.1)	0.0	(0.0)	2.8	(4.1)	7.0	(4.6)	2.3	(11)
	2	7.4	(9.9)			2.8	(4.5)	7.8	(11.3)		
	3	2.4	(5.0)			7.6	(5.1)	4.8	(7.9)		
	4	0.8	(1.2)	0.0	(0.0)	4.0	(9.2)	2.6	(4.8)	0.7	(17)
	5	2.6	(6.2)			5.6	(7.6)	8.0	(14.7)		
	6	1.4	(3.0)			2.4	(6.3)	5.2	(11.2)		
	Stoddart	2.2	(5.7)			1.8	(4.3)	7.8	(26.4)		
Trichoptera	1	0.0	(0.0)	0.0	(0.0)	1.0	(1.5)	1.4	(0.9)	3.7	(18)
	2	0.0	(0.0)			4.0	(6.4)	2.2	(3.2)		
	3	0.2	(0.4)			0.0	(0.0)	1.0	(1.6)		
	4	0.0	(0.0)	0.0	(0.0)	1.2	(2.8)	1.2	(2.2)	0.3	(8)
	5	0.4	(1.0)			0.4	(0.5)	0.2	(0.3)		
	6	0.2	(0.4)			0.0	(0.0)	0.4	(0.9)		
	Stoddart	0.0	(0.0)			0.0	(0.0)	0.2	(0.7)		
Diptera	1	72.6	(63.2)	1.0	(19)	34.4	(50.9)	4.8	(3.1)	1.7	(8)
	2	26.0	(34.8)			27.4	(44.0)	8.2	(11.8)		
	3	21.8	(45.2)			82.0	(54.8)	4.8	(7.9)		
	4	26.8	(41.0)	0.3	(20)	9.0	(20.7)	7.2	(13.2)	2.0	(50)
	5	8.8	(21.0)			32.2	(43.6)	7.6	(13.9)		
	6	28.2	(60.3)			31.0	(82.0)	18.0	(38.6)		
	Stoddart	26.2	(67.9)			13.4	(32.4)	3.0	(10.1)		
Other	1	1.6	(1.4)	0.0	(0.0)	6.6	(9.8)	6.4	(4.2)	2.7	(13)
	2	7.2	(9.6)			7.2	(11.6)	19.4	(28.0)		
	3	1.8	(3.7)			1.6	(1.1)	3.6	(5.9)		
	4	1.6	(2.4)	0.3	(20)	1.8	(4.1)	2.6	(4.8)	0.3	(8)
	5	3.8	(9.1)			2.6	(3.5)	7.2	(13.2)		
	6	0.2	(2.1)			1.6	(4.2)	1.8	(3.9)		
	Stoddart	1.8	(4.7)			5.2	(12.6)	40	(13.5)		

(a) (Mathers et al 1981) Mean from 3 samples.

of dissolved oxygen in the stream water increased at all stations in Big Creek as shown in Section 3.1.3. The change in dissolved oxygen content may partially explain the shift in taxonomic distribution. Wetzel (1975) found that mayflies (Ephemeroptera) and stoneflies (Plecoptera) are restricted to environments with relatively high oxygen content. It is noticed that the Chironomidae Cricotopus sp. is no longer important in the population and considerably reduces the importance of Diptera in September.

Langer (1980) indicates that the Ephemeroptera is known for its inability to survive high sediment content. Another peculiarity of the mayflies is that many species are restricted to specific substrata ie. sediments of specific size (Wetzel 1975). No significant changes in substrate composition could be detected from our data, therefore it is unknown if a change in substrate induced the change in taxonomic composition.

Caddisflies (Trichoptera) show a general increase in numbers from July to September, but are always a very small percentage of the benthic community (<6.5%). It seems that most families of Trichoptera decline in numbers downstream from sediment sources (Pickral 1981) but this taxonomic response to suspended solids (NFR) has not been detected in our results. Coleman and Hynes (1970) point out that the free living forms (Rhyacophilidae) are found in greater numbers between 15-30 cm of sediment depth. This could be one of the reasons why we did not find the Trichoptera in high numbers since sampling was limited to the upper 10-12cm.

Pickral (1981) indicates that certain invertebrates prefer fine sediments under natural conditions and have sometimes displayed an increase in numbers as embedding proceeds, these include chiromonid larvae and tubificid worms. The taxa numbers will not necessarily increase in areas where silts and sand are being deposited, because an area that receives accelerated deposition of sediment generated by human activity may not be comparable to a natural more stable area with fine sediments (Pickral 1981). The change in species composition which occured at all stations on Big Creek, may be attributed to natural seasonal succession.

Diversity Index. The diversity index permits summarization of large amounts of information about the numbers and kinds of organisms and allows numerical comparison to other areas. The ecological basis for the diversity index is that in a polluted area, small numbers of species are found with large numbers of individuals while in clear waters, small numbers of individuals and numerous different species are found (Wilhm 1970). The diversity is affected by factors other than pollution and great emphasis in sampling consistency and accuracy of taxonomic identification must be shown (Hugues 1978). The value of the diversity index may change with the sampling size, number of replicates, depth of sampling as well as the taxonomic level used in the calculation.

The diversity indices calculated in the study (Table 14) show high values in July and August (0.86 to 1.09) except at Stations 3 and 6 where the diversity index in August was 0.75 and 0.68 respectively.

A reduction of the diversity is noticeable in September when the upstream stations have a lower diversity, associated with a low evenness, than the downstream stations. This suggests dominance by one species in the benthic community. The increased numbers of Ephemeroptera, specifically Cinygmula sp. was the factor responsible for the noted reduction in diversity in September. Cinygmula sp. was present in great numbers at each station throughout the study but particularly in the upstream stations. If the species is not included in the count for September (Table 14), the new indices for diversity and evenness would be as follows:

		ST 1	ST 2	ST 3	ST 4	ST 5	ST 6
Diversity Index	H'	1.09	1.03	0.96	1.13	0.87	0.86
Evenness	J'	0.86	0.79	0.72	0.82	0.71	0.59

As shown, the seasonal effect of a single species can noticeably alter the diversity index. This change did not affect the diversity index at Stations 5 and 6.

Community Index. The community index used is represented by the percent similarity index (Psc). The percent similarity index can detect subtle shifts in community composition which can indicate long term trends of change. Table 15 is a similarity index matrix of

TABLE 14 SUMMARY OF NUMBERS OF BENTHIC INVERTEBRATES, DIVERSITY (H') AND EVENNESS (J')

	JULY 24, 1984						
	STATION						
	1	2	3	4	5	6	Stoddart Creek
Total Number of Individuals	574	374	241	327	209	234	193
Total Number at Genus Level	460	296	180	298	169	202	176
Total Number of Genus	21	17	21	21	16	21	15
H'	1.04	0.86	1.09	0.97	0.93	0.96	0.89
J'	0.78	0.70	0.82	0.73	0.77	0.73	0.76

	AUGUST 14, 1984						
	STATION						
	1	2	3	4	5	6	Stoddart Creek
Total Number of Individuals	338	311	748	217	369	189	207
Total Number at Genus Level	294	281	725	204	339	173	179
Total Number of Genus	24	22	18	18	20	18	21
H'	1.01	1.02	0.75	0.94	0.97	0.68	0.96
J'	0.73	0.76	0.60	0.74	0.74	0.53	0.73

	SEPTEMBER 18, 1984						
	STATION						
	1	2	3	4	5	6	Stoddart Creek
Total Number of Individuals	757	346	305	272	273	233	148
Total Number at Genus Level	733	263	282	258	244	217	128
Total Number of Genus	19	21	19	21	24	18	15
H'	0.30	0.76	0.54	0.65	0.89	0.83	0.76
J'	0.23	0.58	0.42	0.49	0.65	0.66	0.65

TABLE 15 PERCENTAGE SIMILARITY INDEX (Psc) OF BENTHIC INVERTEBRATE COMMUNITIES (SPATIAL)

JULY 24, 1984

STATION	2	3	4	5	6	Stoddart
1	54.39	65.28	58.51	48.36	65.82	49.09
2		64.37	46.32	57.91	48.88	35.27
3			55.26	63.78	57.12	40.43
4				62.56	66.18	57.55
5					50.44	35.32
6						71.31

AUGUST 14, 1984

STATION	2	3	4	5	6	Stoddart
1	77.65	62.81	57.07	63.84	42.47	59.89
2		65.82	55.94	59.47	42.98	53.60
3			50.82	61.11	54.20	44.97
4				61.77	33.90	51.04
5					53.88	70.64
6						42.58

SEPTEMBER 18, 1984

STATION	2	3	4	5	6	Stoddart
1	54.13	74.92	66.39	52.90	42.46	16.62
2		54.42	59.17	62.78	49.89	24.03
3			75.72	59.23	55.71	24.68
4				69.67	58.73	22.16
5					65.27	28.75
6						27.87

spatial variation for the three sampling periods on Big Creek. The percentage similarity varies during these sampling periods from 16.62% to 77.65%. In July, Big Creek communities are quite comparable and the downstream stations have over 50% similarity with the upstream station (Station 1). Stoddart Creek Station shows more resemblance to the downstream stations (Stations 4 and 6) in July and Station 5 in August, than to the upstream stations. In August, the similarity between the stations on Big Creek is good except a decrease at Station 6. Stoddart Creek Station shows good similarity with Stations 1, 2, 4 and Station 5 during this period. In September, there was scattered high similarity (over 70%) between Big Creek stations but obvious dissimilarities (less than 30%) between Big Creek stations and Stoddart Creek station (Table 15).

The percent similarity index for temporal variation of benthic communities is given in Table 16. The similarity values for temporal variation are generally lower in comparison to values for spatial variation as described above. These results indicate that temporal changes during the season were greater than spatial changes, that is percent similarity was influenced more by time of season than by sample site location. Station 6 exhibits the greatest percent similarity (temporal) which indicates less community change occured at this station relative to the others during the same period. This similarity value ranged from 45 to 47 percent. Station 4 exhibited similarity index values which ranged from 19 to 50 percent which suggests greater community change occurred at this station relative to others during the same period.

Streambed Sediments

Sediment Particle Size Analysis. The sediment particle size has been assessed by two different methods. The first, the visual method is rapid and subjective. The second, the grab sample method, although more accurate is more time consuming. The results of both methods must be interpreted with caution because of variation in

TABLE 16 PERCENTAGE SIMILARITY INDEX OF BENTHIC COMMUNITIES (TEMPORAL)

STATION	July vs August 1984	July vs September 1984	August vs Sept. 1984
1	34.66	13.93	28.60
2	22.90	27.58	45.29
3	29.52	23.24	35.73
4	25.32	19.47	50.09
5	21.68	35.95	44.97
6	44.97	47.17	47.39
Stoddart Creek	42.04	21.83	44.92

methodology and the extreme variability of streambed particle size composition.

The visual method permits the evaluation of component particles of very large size (boulders, cobbles) (Table 17). The particle size composition in July is relatively consistant between the stations while the values in August and September indicate variability. In August and September, the downstream stations had a higher percentage of the larger fraction (>64mm) and a resultant lower percentage of smaller particle sizes. Station 1 shows a more even distribution between the different size classes.

The grab sample or quantitative evaluation of the particle size is also subject to caution. Firstly, the fines (<63 um), may be washed out during the sampling. Secondly, the gravel size (>2mm), is subject to bias since the larger rocks were selectively removed by hand.

Significant differences could be detected between the seven stations (spatial variation) and between the three different survey periods (temporal variation). These results are shown in Volume 2, Appendix VI, Table 3. A comparison of these results illustrates that differences in sediment composition occur but no specific pattern can be shown. The particle size distribution at Station 6 reflects that this station has the most uniform streambed of all stations for all three sampling dates. This variable pattern of sediment composition makes the interpretation difficult, that is, it cannot be related to spatial or temporal events.

Sampling procedures which adequately retreive sediment from all size classes would also improve the reliability of the results. A diverse substrate is characteristic of a normal stream bed and unless the variability of the sampling methodology is reduced, the evaluation of placer mining effects on the streambed particle size cannot be adequately assessed. To increase the reliability of the results, sampling of streambeds should be comprised of increased members of replicates.

TABLE 17 VISUAL ASSESSMENT OF PARTICLE SIZE (%) ON MAINSTEM BIG CREEK AND STODDART CREEK SEDIMENTS

	STATION 1			STATION 2			STATION 3		
	J	A	S	J	A	S	J	A	S
>64 mm	70	40	30	70	60	30	60	40	30
2-64mm	25	30	60	25	10	30	30	40	50
<2 mm	5	30	10	5	30	40	10	20	20
Organic	-	-	-	-	-	-	-	-	few leaves
TOTALS	100	100	100	100	100	100	100	100	100

	STATION 4			STATION 5			STATION 6		
	J	A	S	J	A	S	J	A	S
>64 mm	60	70	40	70	85	50	80	75	70
2-64 mm	30	25	50	20	5	35	15	15	20
<2 mm	10	5	10	10	10	15	5	10	10
Organic	-	-	-	-	few peri-phyton	few leaves	-	peri-phyton	-
TOTALS	100	100	100	100	100	100	100	100	100

	STODDART CREEK		
	J	A	S
>64 mm	40	60	35
2-64 mm	40	30	40
<2 mm	20	10	15
Organic	-	-	leaves
TOTALS	100	100	100

J = July A = August S = September

A study in Alaska (Van Nieuwenhuyse, 1984) demonstrated that the settlement of sediments on the streambed cut the normal exchanges between the surface water and the groundwater. The use of a sediment trap should be employed as another method to assess the sediments that settle on the streambed, and the compaction that it produces.

Sediment Metal Analysis. The spatial variation in sediment metal content does not significantly change ($p<0.05$) between the Stations 1 to 6 and Stoddard Creek Station in July for the following metals; aluminum (Al), arsenic (As), barium (Ba), beryllium (Be), calcium (Ca), cadmium (Cd), cobalt (Co), iron (Fe), lead (Pb), mercury (Hg), phosphorus (P), potassium (K), silicon (Si), silver (Ag), titanium (Ti) and vanadium (V). Only chromium (Cr) shows a significant spatial difference during the August 14 sampling. It occurs again with copper (Cu) and nickel (Ni) during the September 18 samples (Table 18).

During the July 24 sampling, more differences in concentrations of sediment metals are seen (Volume 2, Appendix VI, Table 4). Generally, Stations 1 and 2 show a similar pattern. They have a higher level of chromium (Cr), magnesium (Mn), Nickel (Ni) and strontium (Sr) and lower levels of copper (Cu) compared to other stations. Chromium (Cr) is the only metal that shows significant differences between stations at all sampling periods.

The temporal variation between stations on Big Creek as shown in Table 19, indicates that sediment metal concentrations differ significantly during the sampling period at various stations. This pattern of variation over time cannot be related to any specific event or activity.

3.3.4 Summary and Recommendations

Benthic Invertebrates

The results provide a good general description of the benthic invertebrate communities of Big Creek and Stoddart Creek. The composi-

TABLE 18 SPATIAL VARIATION OF SEDIMENT METALS BETWEEN STATIONS ON BIG CREEK AND STODDART CREEK ($p<0.05$)

JULY 24, 1984				
Magnesium	(Mg)	Station 1	>	Station 4, 5, 6, Stoddart
Nickel	(Ni)	Station 1	>	Station 4, 5, 6, Stoddart
		Station 2	>	Station 4, 5, 6, Stoddart
Zinc	(Zn)	Station 1	>	Station 4, 6
		Station 2	>	Station 4, 6
Strontium	(Sn)	Station 1	>	Station 3, 4, 5, 6
		Station 2	>	Station 3, 4, 5, 6
Sodium	(Na)	Stoddart	>	Station 1, 2, 3, 4, 5, 6
Copper	(Cu)	Station 1	<	Station 4 and Stoddart
		Station 2	<	Station 4 and Stoddart
Chromium	(Cr)	Station 1	<	Station 4, 5, 6, Stoddart
Selenium	(Se)	Station 3	<	Station 1, 2, 4, 5, 6, Stoddart

AUGUST 14, 1984				
Chromiun	(Cr)	Stoddart	<	Station 2, 4

SEPTEMBER 18, 1984				
Chromium	(Cr)	Stoddart	<	Station 1, 2
Copper	(Cu)	Stoddart	<	Station 3, 4, 5, 6
Nickel	(Ni)	Station 1	>	Station 4, 5, Stoddart
		Station 6	>	Station Stoddart

For Values refer to Volume 2, Appendix VI, Table 4

TABLE 19 TEMPORAL VARIATION OF SEDIMENT METALS BETWEEN STATIONS ON BIG CREEK AND STODDART CREEK ($p<0.05$)

Aluminum	(Al)	July	>	September at Station 2
Barium	(Ba)	July	>	September at Station 4
Calcium	(Ca)	July	>	September at Station 2
Potassium	(K)	July	>	September at Station 2
Magnesium	(Mg)	July	>	September at Stations 2 and 4
Sodium	(Na)	July	>	August at Stoddart
		July	>	September at Stoddart
Phosphorus	(P)	July	>	August at Station 1
		July	>	August at Station 2
Silicon	(Si)	July	>	August at Station 2
		September	>	August at Station 5
Tin	(Sn)	August	>	July at Station 3
Strontium	(Sr)	July	>	August at Stations 2 and 4
Titanium	(Ti)	July	>	August at Station 2
Vanadium	(V)	September	>	August at Station 2

For values refer to Volume 2, Appendix VI, Table 4

tion is similar to that reported by Mathers et al (1981) however densities are greater in the present study.

Temporal variation in community composition and structure during the season was demonstrated using densities of taxonomic groups to illustrate that the Ephemeroptera, Diptera and Trichoptera are the dominant groups. The Diptera becomes less predominant later in the season and the Trichoptera becomes more abundant.

Calculation of diversity indices for the benthic invertebrate communities at each station on each sampling date reveals generally high diversities. September is an exception because of the dominance by one genus Cinygmula sp.

The use of percent similarity as a representation of the community indices, compares benthic invertebrate communities. This study reveals considerable variation of community structure and composition through time and space.

The comparison of Stoddart Creek station with Big Creek stations reveals that on September 18 the invertebrate community had lower similarity with Big Creek stations than on previous sampling dates. In terms of temporal percent similarity, Station 6 reveals the greatest uniformity between sample dates (45%-47%).

The benthic invertebrate community is seen to vary temporally due to natural seasonal succession and naturally changing environmental conditions. The benthic community is also seen to vary spatially within the study area. However, this variability could not be correlated with any activity or event based on the data available.

Sediment Characteristics

The result of sediment particle size analysis provides a visual description and quantitative measure of streambed sediments at the sample locations. The data shows a high degree of temporal and spatial variability in streambed composition. Because of this high degree of variability, the particle size distribution cannot be related to spatial or temporal activities and events. Station 6 exhibits the

degree of variability, the particle size distribution cannot be related to spatial or temporal activities and events. Station 6 exhibits the greatest uniformity in particle size composition during the sampling periods which may be a factor in influencing the relative percent similarity of the benthic invertebrate community.

The leachable metals results provide a general overview of sediment chemistry at the various sample stations. Statistically significant differences were observed for some metals, particularly when comparing Stations 1 and 2 with other sample sites, however, no temporal or spacial patterns were obvious.

If surficial geological investigations indicate good potential for continued placer mining activity in Big Creek drainage, it is recommended that:

1. Monitoring studies with respect to benthic invertebrates and streambed sediment characteristics be focussed more on mined tributaries of Big Creek while maintaining upstream and downstream stations on Big Creek for baseline comparison;
2. The benthic invertebrate and streambed sediment monitoring studies be done in association with other studies related to sediment loading and transport in the tributary stream and downstream;
3. The monitoring studies should be in greater detail, with regard to frequency of sampling, period or duration of sampling during the season and over a period of more than one season, to permit adequate characterization of background conditions;
4. Sediment sampling methods be modified to improve quantitative measurements and additional replicates be collected to reduce the variation in the data.

4 FUTURE RESEARCH AND MONITORING ACTIVITY IN THE BIG CREEK DRAINAGE

The objective of having information to evaluate the area for long term research and monitoring activity has been achieved to varying degrees by different government agencies as a result of activities undertaken during 1984.

The recommendations made by the contributing government agencies suggest four approaches to continued environmental research and monitoring that could be pursued by government agencies if considered appropriate. These approaches include:

1. further assessment of the suitability of the area as a demonstration drainage;
2. performing studies to address specific policy related issues;
3. general research as related to mining, aquatic and terrestrial ecology, and;
4. adapting the survey method of information collection to other drainages.

These approaches are not exclusive and several could proceed simultaneously.

The first approach would be to address existing information gaps that will allow a thorough assessment of suitability of the area as a demonstration drainage and complete the survey effort begun in 1984. There is a general consensus among the government agencies involved that the placer mining potential of the area has to be reviewed. A detailed placer deposit geology investigation would be valuable to this end. Other terrestrial environmental characteristics such as soil type and slope also need to be examined. This information would be used to evaluate cause-effect relationships and the transferability of results.

The second approach would be to conduct research and monitoring that has direct policy implications or that will address specific policy issues. The activities included here are:

a) Continued monitoring of water quality in the mainstem of Big Creek and the placer mined tributaries with emphasis on the transport of

placer generated sediment levels. Linkage between Class A and B streams and lower classified tributaries and the movement of sediments within the system would be examined.

b) Monitoring of benthic invertebrates and sediment characteristics should be integrated with (a) above to consider the linkage relationships between lower classified tributaries and Class A or B streams.

c) Grayling spawning and rearing in the drainage, timing and extent of upstream migration of chinook salmon fry, and spawning of chinook salmon in small watersheds not buffered by headwater lakes should be investigated. This activity would improve inventory information for stream classification and understanding of fish behavior in this drainage.

These alternate activities could occur independently of one another. although there would be operational savings by integrating (b) with (a)

The third approach would be to conduct research and monitoring to add to the knowledge base of the area and have indirect policy implications but would primarily focus on developing an understanding of system processes. Included here are ideas related to rehabilitation in streams and changes to stream morphology and substrate as a result of increased sediment loads. This activity could occur in any suitable area.

The fourth approach would be to take the present study format and design, with the identified modifications, and undertake survey level studies in other drainages to provide a base level of information useful to resource management decisions. The clear identification of an integrated study team and a firm committment to fund and undertake respective activities would be required by each government agency.

4.1 Recommendations and Needs

There is a need for decisions to be made on the value of undertaking environmental impact research and monitoring before long term programs are implemented.

It is recommended that the perceived placer potential, based on current industry and government knowledge, of the Big Creek area be used to direct further work.

- Given there is future development potential, it is recommended that a combination of approaches 1 and 2 be undertaken in the short term. This would address certain specific information gaps and policy issues.
- Given there is limited development potential in this area, it is recommended that approach 4 be implemented in other placer drainages. This would involve information collection at the survey level.

An investigation of the placer geology should be completed before long term programs are implemented.

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NOTES

APPENDIX I

ENVIRONMENTAL ASSESSMENT OF A SELECTED PLACER STREAM

STUDY PROPOSAL

BACKGROUND

At the May 11, 1984 meeting of the Joint Committee on Placer Mining Research and Development, government and industry representatives supported the concept of a study, or studies, to undertake an environmental assessment of placer mining. As outlined this would occur in one, or a few, location(s) depending on the resources committed, the intensity of the study and finding suitable locations. The project is part of a larger program to gather information so that a profile of the industry could be developed. Interest in participating in this component of the program was expressed by DIAND Renewable Resources, YTG Renewable Resources, DFO and DOE (EPS). Meetings were subsequently held to discuss the potential input from each agency, the objectives of the project and to select potential study areas based on specific criteria.

OBJECTIVES

The primary objectives of jointly undertaking the proposed assessment are to:

a) gather information such as water quality, stream flow, aquatic resources (fish and invertebrates), wildlife data, outdoor recreation potential and land use information that will be of value for environmental assessment and dealing with issues on the particular stream selected;
b) gather data and results that are transferable in varying degrees to other streams;
c) explore the potential for establishing a permanent "demonstration stream" or "demonstration drainage" as a basis for long term research and monitoring.

Achieving the above objectives will encourage cooperation among government agencies and miners in a practical, non-confrontational working environment.

POTENTIAL STUDY AREAS

Three streams are being considered based on a review and selection process that rated 8 factors in relation to the primary issue of downstream linkages and presence of Schedule I fish, i.e. salmon, and trout, as used in the Stream Classification System.

The streams being considered are:

a) Big Creek i) main stem
ii) selected tributaries and main stem

b) Granite Creek (Haines Junction area)

c) Seven Mile Creek (Aishihik Road)

From consideration of these three streams, 4 possible study areas result. The factors considered and evaluation of the three potential streams is provided below. Rating of each factor was on a scale of 1 to 3, higher numbers reflecting a more favourable status for that factor, e.g. difficult access would score low.

	BIG CREEK			
	Main Stem	Main & Tributary	GRANITE CREEK	SEVEN MILE CREEK
Access	2	2	2	2
Transferability of Information	3	3	2	2
Scale of Mining	3	3	2	1
Linkages of downstream classification	3	3	3	3
Scope of study/ Resources required	2	1	3	3
Existing Data	3	2	2	2
Suitability of longer term study	3	3	2	1
Immediate Benefit	3	3	2	1

On the basis of the evaluation and rating according to these factors a study involved with the mainstem of Big Creek, treating the tributaries as point sources of disturbance, is most suitable and the recommended option of the four options considered. A close second is to include tributaries in the project but this increases the costs, personnel requirements and time. Granite Creek and Seven Mile Creek follow close behind the Big Creek area in terms of suitability.

Project Details and Agency Involvement

The intent of a coordinated project is to cooperate to the extent possible among agencies in field visits and sampling. The field sampling program would be identified at the project start up and joint field investigation and sampling will minimize any duplication of travel or field work.

The various agencies interests and field/office activities are as follows, assuming the recommended study area is acceptable. Minor alterations to the activities would be necessary if other options are chosen.

DIAND: Water Resources

Will monitor water quality and stream flow at key points in the watershed.

1) Up to 8 water quality stations would be established and sampled on a monthly basis for chemical constituents during the 1984 operating season.
2) Stream flow will be monitored at the same time and location as water quality samples are taken to allow calculation of material loadings. Also, up to two continuous stream flow guaging stations will be installed to show changes in flow regimes.

DIAND: Land Resources

Will, in cooperation with YTG Renewable Resources, provide:

1) a general overview of land use actvities in the area;
2) a review of the sequential development of the road system in the area;
3) a regional overview of surficial geology relating sensitive terrain features and areas.

The information collected will be generated in map form for the area.

YTG: Renewable Resources

Will provide manpower and resources to cooperate with DIAND Land Resources to:

1) Develop a general perspective on land use issues relating to the selected stream;
2) Undertake a technical assessment of the implications for wildlife, outdoor recreation, and watershed rehabilitation in the selected watershed;
3) Work in cooperation with DFO on an appropriate stream habitat assessment. Details to be agreed on with DFO.

DFO: Habitat Management

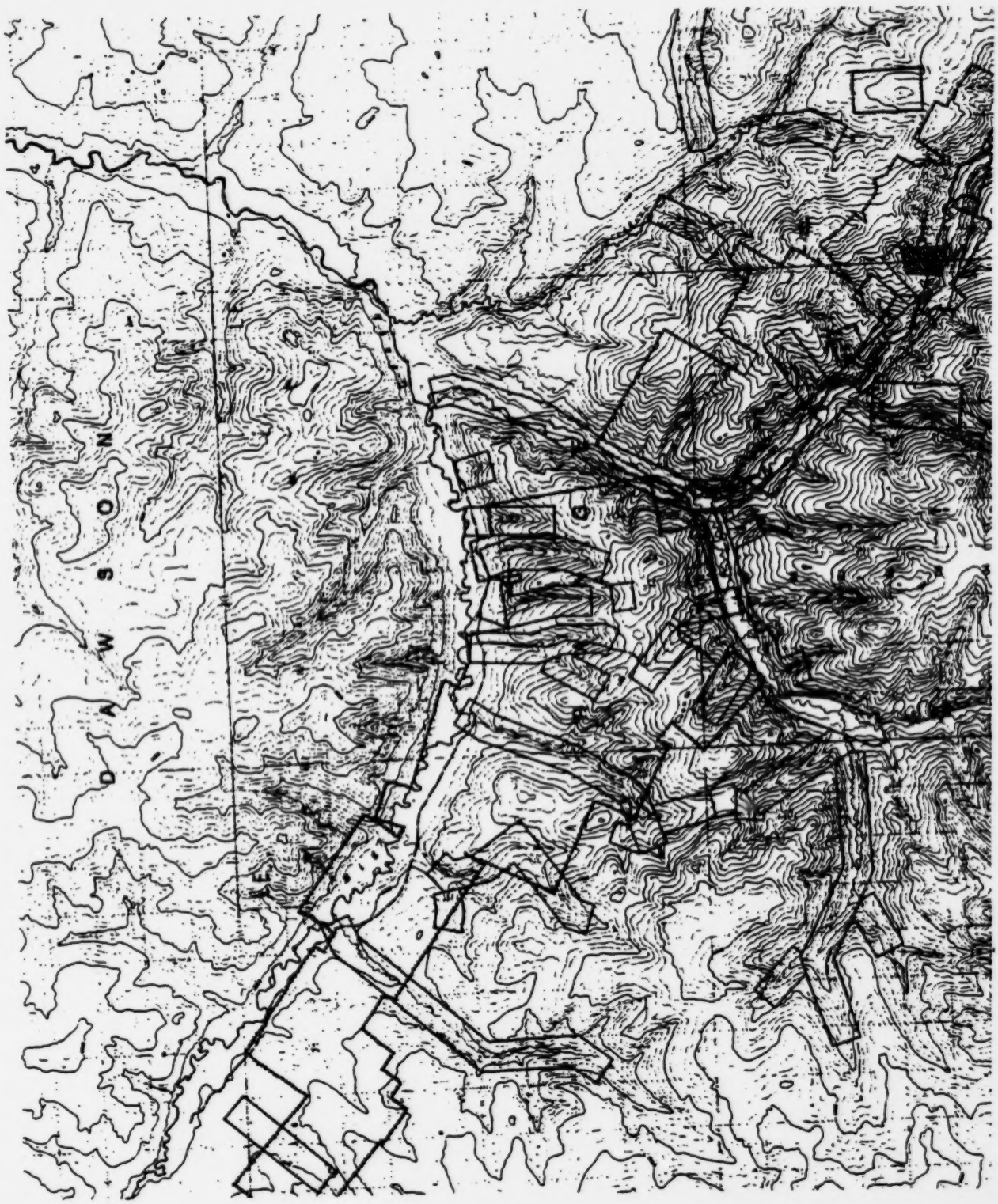
Will float Big Creek from the "A" Classification level to it's confluence with the Yukon River to look for the presence of spawning adult chinook salmon or spawned out carcasses to provide better data base for stream classification. The float investigation will be supplemented by fixed wing aircraft survey of the same area if possible.

DOE: Environmental Protection Service

1) Will monitor benthic invertebrate populations and sediment composition and chemistry at key points in the watershed. The station locations will correspond with the water quality monitoring stations and will be selected on site in discussion with DIAND Water Resources. Sampling will done on a monthly basis at the same time as DIAND Water Resources collect water quality and stream flow data.
2) Aerial photography, using the Light Aircraft Camera System (LACS) may be possible during the summer of 1984. The LACS system is capable of producing inexpensive aerial photography of a quality that is useful for air photo interpretation by land use planners and resource managers. The project will utilize the photography if it is available. Subject to the LACS system being operational and available funding, Big Creek and the tributaries in the study area will be flown to provide aerial photo coverage at an appropriate scale.

APPENDIX II

PLACER/QUARTZ BOUNDARIES FOR THE BIG CREEK STUDY AREA



BOUNDARIES

Placer Claims

Quartz Claims

APPENDIX II CLAIMS MAP

APPENDIX III

COLLECTION, PRESERVATION, ANALYSIS OR IDENTIFICATION METHODS AND WATER QUALITY CRITERIA

APPENDIX III TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Temperature		In situ temperature reading.	Standard Centigrade Thermometer	
Flow		In situ flow measurements using a Price-type current meter.	Cross-section of the stream was measured and the velocity of flow was calculated using the standard Price-type Current Meter Method[3].	
Dissolved Oxygen	1.00 mg/l	Duplicate samples collected in 300 ml glass BOD bottles. The BOD bottles were rinsed 3 times with sample before filling. Preserved with 2 ml manganese sulphate and 2 ml alkali-iodide-azide solution and shaken 15 times. A water seal was maintained and DO analysis was done within 2 days.	Iodometric Azide Modification Winkler Titration Method	048
pH		Small aliquots of sample were taken and read soon after collection. No preservative.	Potentiometric	080
Conductivity	0.2 umhos/cm	In situ measurement. Laboratory measurement. No preservative. The measurement was taken from the same as turbidity below.	YSI Conductivity Meter Model 33 Radiometer Conductivity Meter (CDMC) with radiometer conductivity cell.	044

APPENDIX III TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Turbidity	0.1 (FTU)	Single samples collected in 2 litre linear polyethylene containers. Each container was rinsed 3 times with sample before it was filled. No preservatives. Stored at 4°C.	Nephelometric Turbidity	130
Settleable Solids	0.1 mg/l	Same collection procedure as for Turbidity.	Settleable Matter	112
Non-Filterable Residue (NFR)	5.0 mg/l	Same sample as Turbidity.	Filtration, drying and weighing of residue on filter	104
Filterable Residue (FR)	10.0 mg/l	Same sample as Turbidity.	Filtration, drying and weighing of filtrate	100
Total Alkalinity	1.0 mg/l as $CaCO_3$	Same sample as Turbidity.	Potentiometric Titration	006
Total Phosphate T PO_4-P	0.005 mg/l	Same sample as Turbidity.	Acid-persulphate, Autoclave Digestion	086
Nitrate NO_2-N	0.005 mg/l	Same sample as Turbidity.	Diazotization-Colorimetric-Automated	070
Nitrate NO_3-N	0.01 mg/l	Same sample as Turbidity.	Cadmium Copper Reduction Colorimetric Automated	072
Sulphate SO_4	1.0 mg/l	Same sample as Turbidity.	Barium Chloranilate -UV Spectrophotometric	122

APPENDIX III TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Chloride Cl	0.5 mg/l	Same sample as Turbidity.	Thiocyanate-Combined Reagent-Colorimetric	024
Mercury Total Hg	0.0005 mg/l	Single samples were collected in a 100 ml linear polyethylene bottle. Preserved with a 5 ml 5% nitric dichromate solution.	Open Flameless System for Hg-AAS Determination	211 224 284 411
Extractable Metals	mg/l	Single samples collected in 100 ml linear polyethylene bottles. Each bottle was rinsed 3 times with sample before filling. Preserved to a pH <1.5 using 0.5 ml concentrated HNO_3.	Inductively Coupled Argon Plasma (ICAP) combined with Optical Emission Spectrometer (OES)	201 592
Al	0.05			
As	0.05			
Ba	0.0015			
Be	0.001			
Ca	0.050			
Cd	0.002			
Co	0.005			
Cr	0.005			
Cu	0.005			
Fe	0.005			
Mg	0.10			
Mn	0.001			
Mo	0.005			
Na	0.5			
Ni	0.02			
Pb	0.02			
Sb	0.05			
Se	0.05			
Sn	0.01			

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Sr	0.002			
Tl	0.002			
V	0.01			
Zn	0.005			
Total Hardness	0.030 mg/l as $CaCO_3$	Same sample as metals.	The sum of the ICAP results for Mg x 4.116 and Ca x 2.497 reported as mg/l $CaCO_3$	

1 As described in Environment Canada (1976).

2 As described in Department of Environment (1979).

APPENDIX III TABLE 3 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS

PARAMETER	COLLECTION/PREPARATION	ANALYSIS	METHOD CODE[1]
All Parameters	Creek Stations: Sediment samples were collected using an aluminum shovel to scoop sample into pre-labelled geochemical sampling bags within Whirl-Pak™ bags. Three samples were taken at each station. Samples were kept cool and were frozen (-19°C) as soon as possible.		
Mercury Hg (Total)	Sample was freeze-dried for 48 hours to remove water. Sample was sieved through a size 100 mesh (.15 mm) stainless steel sieve. The portion passing through the selve was analyzed for mercury. Sample was completely oxidized by digestion with H_2SO_4 and H_2O_2.	Mercury Monitor	370
Metals (Leachable) Al, Ba, Ce Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Na, Ni, P, Pb, Si, Sn, Sr, Ti, V, Zn	Same as Mercury except portion passing through was analyzed for metals. Sample was leached with HCL and HNO_3. The sample was heated for 3 hours.	Inductively Coupled Argon Plasma (ICAP)	320

APPENDIX III TABLE 3 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS (continued)

PARAMETER	PREPARATION	ANALYSIS	METHOD CODE[1]
Metals (Leachable) (continued)			
As	Same as other metals.	Hydride Generation-ICAP	350
Ag	Same as other metals.	Flame Atomic Absorption Spectrophotometry	330
K	Same as other metals.	Flame Atomic Emission Spectrophotometry	340
Particle Size	Sample was freeze-dried.	Standard Sieving Operation	078

[1] Department of Environment, Department of Fisheries and Oceans, Laboratory Manual, Environmental Protection Service, Fisheries and Marine Service (1979).

APPENDIX III TABLE 2 BOTTOM FAUNA COLLECTION, PRESERVATION AND IDENTIFICATION METHODS

FIELD COLLECTION, SAMPLING PROCEDURES AND PRESERVATION	LABORATORY PROCEDURES	IDENTIFICATION AND ENUMERATION
Surber Sampler: Benthic invertebrate samples were collected from the creek bed using a Surber Sampler with a 60 cm long net(mesh size 0.363 mm). Area sampled was 900 cm^2 (1 ft^2). Surber samples were washed into a cup at the bottom of a plankton net (0.363 mm mesh size), put in separate labelled glass jars and preserved with 10% formalin. Five samples were taken at each station. Samples were taken near the bank below the low water level, and selected for their representativeness of the streambed on both sides of the riffle as much as possible. Samples were taken not deeper than 1 foot (0.5 meters). Station 6 was too deep to sample on both sides. For each sample the gravel was agitated for up to a minute to a depth of and 10 to 12 cm.	Bottom fauna was removed from other material in a labelled vial containing 70% methanol.	Bottom fauna was sent to Dr. C. Low, Consulting Invertebrate Biologist, Nanaimo, B. C. for identification to genus, species if possible, and enumeration.

APPENDIX III TABLE 4 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Physical				
Turbidity J.T.U.	5	1		
Chemical				
Alkalinity mg/l (Total)	Not considered a public health problem	4	>20	3
Aluminum (Al) mg/l	Not considered a public health problem	7	0.1	5
Antimony (Sb) mg/l				
Arsenic (As) mg/l	0.05	1	0.05	2
Barium (Ba) mg/l	1.0	1	5.0	7
Boron (Bo) mg/l	1.0	1		
Cadmium (Cd) mg/l	0.005	1	0.0002	2
Calcium (Ca) mg/l	75-200	7		
Chloride (Cl)mg/l	250	1		
Chromium (Cr) mg/l	0.05	1	0.04	2
Cobalt (Co) mg/l				
Conductivity @ 25°C (umhos/cm)	Depends on dissolved salts	7	150-500	6
Copper (Cu) mg/l	1.0	1	0.005	5
Dissolved oxygen (% saturation)	Near 100%	4	$\geq$5.0 mg/l	3
Hardness (Total) as mg/l $CaCO_3$	80-100	1		
Iron (Fe) mg/l	0.3	1	1.0	3
Lead (Pb) mg/l	0.05	1	0.005 (soft H_2O*)	2
			0.01 (hard H_2O*)	2
Magnesium (Mg) mg/l	50	4		
Manganese (Mn) mg/l	0.05	1	1.0	7
Mercury (Hg) mg/l	0.002	1	0.0001-0.0002	2

APPENDIX III TABLE 4 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Molybdenum (Mo)				
Nickel (Ni) mg/l	0.25	2	0.025 (soft H_2O*)	2
			0.25 (hard H_2O*)	2
Nitrate (NO_3-N) mg/l	10	1		
Nitrite (NO_2-N) mg/l	0.001	1		
pH units	6.5 - 8.5	1	6.5 - 9.0	3
Phosphorus (P) mg/l (Total)			0.020 to prevent algae	5
Residue: Filterable mg/l (Total dissolved solids)	1000	4	70 - 400 with a maximum of 2000	6
Residue: Non-Filterable (mg/l)				
Selenium (Se) mg/l	0.01	1	0.01	2
Silica (Si) mg/l				
Sodium (Na) mg/l	20	1		
Strontium (Sr) mg/l	10	1		
Sulphate (SO_4) mg/l	500	1		
Tin (Sn) mg/l	Not present in natural waters	7		
Titanium (Ti) mg/l				
Vanadium (V)				
Zinc (Zn) mg/l	5.0	1	0.030	5

* Soft water has a total hardness less than 95 mg/l as $CaCO_3$. Hard water has a total hardness of more than 95 mg/l as $CaCO_3$ (Reference 6).

REFERENCES:

1. Health & Welfare Canada, Guidelines for Canadian Drinking Water Quality 1978, Supply and Services, Canada (1979).

APPENDIX III TABLE 4 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)

2. Inland Waters Directorate, Guidelines for Surface Water Quality, Vol. 1, Inorganic Chemical Substances. Environment Canada, Ottawa (1979, 1980).

3. Thurston, R.V., R.C. Russo, C.M. Fetterolf Jr., T.A. Edsall, and Y.M. Barber Jr. (Eds.), A Review of the EPA Red Book: Quality Criteria for Water. Water Quality Section, American Fisheries Society, Bethesda, MD, 313p. (1979).

4. Anonymous, Guidelines for Establishing Water Quality Objectives for the Territorial Waters of the Yukon and Northwest Territories. Report of the Working Group on Water Quality Objectives to the Chairmen, Water Boards, Yukon and Northwest Territories, July (1977).

5. Ontario Ministry of the Environment, Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment. (1978).

6. Environment Canada, Pollution Sampling Handbook. Pacific Region Laboratory Services, Fisheries Operations and Environmental Protection Service, West Vancouver, B.C. (1976).

7. California State Water Resources Control Board, Water Quality Criteria. Publication No. 3-A Second Edition by McKee and Wolf. (1963).

Volume

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VOLUME 2

AN ENVIRONMENTAL OVERVIEW OF BIG CREEK, YUKON AS RELATED TO PLACER MINING ACTIVITY

DATA APPENDICES

APPENDIX I

WATER QUALITY DATA
BIG CREEK PLACER OPERATIONS
1984

APPENDIX I WATER QUALITY DATA, DIAND PLACER MINING SAMPLING PROGRAM, 1984

WATER QUALITY PLACER BIG CR. STUDY Stream name	Operator	Licence #	Sample Local E=Effluent U=Upstream D=Downstream B=Background S=Sluice O=Other	Sample # 84-	Sample Date 1984	Settleable Solids ml/l	Suspended Solids mg/l	Clarity Wedge	Turbidty J.T.U	pH
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	B	84-007	MAY 29	<0.1	13.0	46	18	7.7
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	E	84-008	MAY 29	3.5	2732.0	4	350	7.5
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	D	84-009	MAY 29	0.4	280.0	21	33	7.7
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	B	84-010	JUNE 5	0.3	30.6	46	10	7.5
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	D	84-011	JUNE 5	0.5	245.0	22	36	7.6
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	E	84-012	JUNE 5	3.2	4432.0	3	1275	7.4
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	O	84-013	JUNE 5	0.3	61.5	46	11	7.5
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	E	84-043	JULY 16	<0.1	136.8	19	300	7.4
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	D	84-046	JULY 16	<0.1	14.0	46	25	7.9
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	O	84-047	JULY 16	<0.1	1.2	46	6	7.6
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	D	84-048	JULY 17	<0.1	137.2	19	200	7.5
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	E	84-049	JULY 17	<0.1	637.0	6	960	7.3
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	O	84-050	JULY 17	<0.1	12.8	46	17	7.5
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	O	84-041	JULY 18	<0.1	1.2	46	3	7.8
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	D	84-052	JULY 18	<0.1	222.0	11	320	8.1
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	E	84-053	JULY 18	<0.1	382.0	9	480	7.7
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	D	84-067	JULY 25	<0.1	47.0	25	3	7.8
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	B	84-068	JULY 25	<0.1	2.0	46	160	7.8
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	E	84-069	JULY 25	<0.1	282.0	12	340	7.8
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	B		AUG 16	<0.1	1.8	46	7	7.6
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	D		AUG 16	<0.1	194.7	17	135	7.8
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	E		AUG 16	0.1	434.0	9	375	7.5
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	B	84-082	AUG 23	<0.1	9.3	46	4	7.6
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	E	84-083	AUG 23	0.7	748.0	6	470	7.4
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	D	84-084	AUG 23	0.1	282.0	14	152	7.4
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	B		SEPT 17	<0.1	2.0	46	4	7.6
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	D		SEPT 17	<0.1	13.2	46	19	7.8
SEYMOUR CREEK	GRANGER	Y-PM-84-04-L	E		SEPT 17	<0.1	3.6	46	11	7.9
MECHANIC CREEK	COLES	Y-PM-84-29	B	84-086	AUG 23	<0.1	6.5	46	7	7.0
MECHANIC CREEK	COLES	Y-PM-84-29	D	84-087	AUG 23	<0.1	281.0	8	630	7.1
MECHANIC CREEK	COLES	Y-PM-84-29	E	84-088	AUG 23	<0.1	1870.0	2	2940	6.8
MECHANIC CREEK	GUDER MINES	Y-PM-84-250	B	84-086	AUG 23	<0.1	6.5	46	7	7.0
MECHANIC CREEK	GUDER MINES	Y-PM-84-250	E	84-090	AUG 23	0.2	3730.0	1	2520	6.0
MECHANIC CREEK	GUDER MINES	Y-PM-84-250	D	84-091	AUG 23	<0.1	261.3	9	370	6.8
REVENUE CREEK	DJUKASTEIN	Y-PM-84-234	E	84-051	JULY 17	<0.1	644.0	5	1020	7.0
CABIN GULCH	BANKS	Y-PM-84-65	B	84-045	JULY 16	<0.1	1.2	46	2	7.1
CABIN GULCH	BANKS	Y-PM-84-65	E	84-044	JULY 16	0.7	132.4	20	200	6.6

APPENDIX II WATER QUALITY DATA, DIAND PLACER MINING SAMPLING PROGRAM

Stream name	Operator	Conductivity umhos/cm	General comments
SEYMOUR CREEK	GRANGER	150	
SEYMOUR CREEK	GRANGER	165	OPERATOR SLUICING WHILE SAMPLING
SEYMOUR CREEK	GRANGER	158	OPERATOR SLUICING WHILE SAMPLING
SEYMOUR CREEK	GRANGER	112	BACKGRD SAMPLE SITE C
SEYMOUR CREEK	GRANGER	117	
SEYMOUR CREEK	GRANGER	135	ONSITE IMHOFF CONE = 2.8 ml/l
SEYMOUR CREEK	GRANGER	112	BACKGRD SAMPLE OF DIVERSION CHAN
SEYMOUR CREEK	GRANGER	250	NOT SLUICING DURING SAMPLING
SEYMOUR CREEK	GRANGER	242	NOT SLUICING DURING SAMPLING
SEYMOUR CREEK	GRANGER	241	BACKGRD SAMPLE OF DIVERSION CHAN
SEYMOUR CREEK	GRANGER	245	SLUICING
SEYMOUR CREEK	GRANGER	247	SLUICING
SEYMOUR CREEK	GRANGER	245	BACKGRD SAMPLE OF DIVERSION CHAN
SEYMOUR CREEK	GRANGER	217	BACKGRD SAMPLE OF DIVERSION CHAN
SEYMOUR CREEK	GRANGER	208	SLUICING
SEYMOUR CREEK	GRANGER	262	SLUICING
SEYMOUR CREEK	GRANGER	280	SLUICING PRIOR TO SAMPLING
SEYMOUR CREEK	GRANGER	297	BACKGRD SAMPLE SITE C
SEYMOUR CREEK	GRANGER	287	SLUICING PRIOR TO SAMPLING
SEYMOUR CREEK	GRANGER	291	BACKGRD SAMPLE SITE C
SEYMOUR CREEK	GRANGER	258	SLUICING
SEYMOUR CREEK	GRANGER	270	SLUICING
SEYMOUR CREEK	GRANGER	270	BACKGRD SAMPLE OF DIVERSION CHAN
SEYMOUR CREEK	GRANGER	272	SLUICING
SEYMOUR CREEK	GRANGER	268	SLUICING
SEYMOUR CREEK	GRANGER	286	BACKGRD SAMPLE SITE C
SEYMOUR CREEK	GRANGER	264	NOT SLUICING
SEYMOUR CREEK	GRANGER	319	NOT SLUICING
MECHANIC CREEK	COLES	165	UPPERMOST BACKGRD SAMPLE
MECHANIC CREEK	COLES	179	SLUICING
MECHANIC CREEK	COLES	230	SLUICING
MECHANIC CREEK	GUDER MINES	165	UPPERMOST BACKGRD SAMPLE
MECHANIC CREEK	GUDER MINES	188	SLUICING
MECHANIC CREEK	GUDER MINES	172	SLUICING
REVENUE CREEK	DJUKASTEIN	165	SLUICING 16 HRS PRIOR TO SAMPLE
CABIN GULCH	BANKS	247	U/S OF OPERATION
CABIN GULCH	BANKS	117	SLUICING

APPENDIX II

WATER QUALITY DATA
BIG CREEK AND STODDART CREEK

APPENDIX II TABLE 1 BIG CREEK MAINSTEM WATER QUALITY

STATION	DATE 1984	TIME	FLOW cms'	TEMP. C	pH UNITS	CONDUCTIVITY umhos/cm	TURBIDITY F.T.U.	N.F.R. mg/l	F.R. mg/l	T. ALKALINITY mg/l CaCO
BCST1	JULY 24	1715	1.823	11.9	7.3	134	0.1	<5.0	108	55.0
BCST1	AUG 14	1424	1.927	9.0	7.5	152	<0.1	<5.0	118	67.0
BCST1	SEPT 18	1315	4.068	4.0	7.5	133	<0.1	<5.0	112	59.0
AVERAGE =			2.606	8.3	7.4	140	0.1	5.0	112.7	60.3
STANDARD DEV. =			1.267	4.0	0.1	11			5.0	6.1
BCST2	JULY 24	1628	1.890	11.1	7.3	136	<0.1	<5.0	107	56.0
BCST2	AUG 14	1530	2.133	12.0	7.5	154	<0.1	<5.0	120	62.5
BCST2	SEPT 18	1445	4.467	4.1	7.5	139	<0.1	<5.0	132	57.0
AVERAGE =			2.830	9.1	7.4	143	<0.1	5.0	119.7	58.5
STANDARD DEV. =			1.423	4.3	0.1	10			12.5	3.5
BCST3	JULY 24	1515	1.751	12.1	7.3	134	2.3	<5.0	104	54.0
BCST3	AUG 14	1920	1.484	10.4	7.5	149	0.8	<5.0	118	59.5
BCST3	SEPT 18	1705	4.512	4.0	7.5	142	1.5	<5.0	117	55.0
AVERAGE =			2.582	8.8	7.4	142	1.5	5.0	113.0	56.2
STANDARD DEV. =			1.676	4.3	0.1	8	0.8		7.8	2.9
BCST4	JULY 24	1242	2.334	11.0	7.3	134	8.6	7	105	55.0
BCST4	AUG 14	1240	2.513	7.1	7.5	150	3.1	10	122	61.5
BCST4	SEPT 18	1230	4.982	4.0	7.5	142	0.1	<5.0	114	58.0
AVERAGE =			3.276	7.4	7.4	142	3.9	7.3	113.7	58.2
STANDARD DEV. =			1.480	3.5	0.1.	8	4.3	2.5	8.5	3.3
BCST5	JULY 24	1310	3.295	11.2	7.4	140	7.0	10	112	61.0
BCST5	AUG 14	1213	3.746	5.9	7.6	180	12.3	22	137	73.0
BCST5	SEPT 18	1130	6.842	2.0	7.6	172	0.3	<5.0	127	70.0
AVERAGE =			4.628	6.4	7.5	164	6.5	12.3	125.3	68.0
STANDARD DEV. =			1.931	4.6	0.1	21	6.0	8.7	12.6	6.2
BCST6	JULY 24	955	3.814	10.0	7.5	153	21.0	24	120	64.0
BCST6	AUG 14	1030	4.274	5.1	7.7	167	9.4	16	136	68.5
BCST6	SEPT 18	938	6.828	2.0	7.6	156	0.3	<5.0	116	64.0
AVERAGE =			4.972	5.7	7.6	159	10.2	15.0	124.0	65.5
STANDARD DEV. =			1.624	4.0	0.1	7	10.4	9.5	10.6	2.6
BIG CREEK STATIONS:	JULY	AVERAGE=	2.485	11.2	7.4	138.5	6.5	9.3	109.3	57.5
BIG CREEK STATIONS:	JULY	ST.DEV.=	0.869	0.7	0.1	7.5	7.9	7.4	5.9	4.0
BIG CREEK STATIONS:	AUG	AVERAGE=	2.680	8.3	7.6	158.7	4.3	10.5	125.2	65.3
BIG CREEK STATIONS:	AUG	ST.DEV.=	1.096	2.7	0.1	12.3	5.3	7.1	8.9	5.1
BIG CREEK STATIONS:	SEPT	AVERAGE=	5.283	3.4	7.5	147.3	0.4	5.0	119.7	60.5
BIG CREEK STATIONS:	SEPT	ST.DEV.=	1.236	1.0	0.1	14.3	0.5		8.0	5.5

APPENDIX 11 TABLE 1 BIG CREEK MAINSTEM WATER QUALITY (CONTINUED)

STATION	DATE	T. HARDNESS mg/l CaCO	DISS. HARDNESS mg/l CaCO	DISS. PHOSPHATE mg/l	DISS. NITRITE mg/l	DISS. NITRATE mg/l
BCST1	JULY 24	72.3	58.0	0.010	<0.005	0.03
BCST1	AUG 14	66.1	66.6	0.016	<0.005	0.06
BCST1	SEPT 18	65.5	55.3	0.009	<0.005	0.05
AVERAGE =		68.0	60.0	0.012	<0.005	0.05
STANDARD DEV. =		3.8	5.9	0.004		0.02
BCST2	JULY 24	83.9	60.9	0.007	<0.005	0.03
BCST2	AUG 14	67.1	65.8	0.027	<0.005	0.07
BCST2	SEPT 18	68.3	57.4	0.007	<0.005	0.06
AVERAGE =		73.1	61.4	0.014	<0.005	0.05
STANDARD DEV. =		9.4	4.2	0.012		0.02
BCST3	JULY 24	70.6	57.3	0.007	<0.005	0.03
BCST3	AUG 14	66.1	64.5	0.007	<0.005	0.04
BCST3	SEPT 18	70.5	56.3	0.008	<0.005	0.09
AVERAGE =		69.1	59.4	0.007	<0.005	0.05
STANDARD DEV. =		2.6	4.5	0.001		0.03
BCST4	JULY 24	67.2	59.4	0.007	<0.005	0.06
BCST4	AUG 14	68.8	64.7	0.031	<0.005	0.08
BCST4	SEPT 18	70.3	57.6	0.008	<0.005	0.08
AVERAGE =		68.8	60.6	0.015	<0.005	0.07
STANDARD DEV. =		1.6	3.7	0.014		0.01
BCST5	JULY 24	65.5	59.1	0.011	<0.005	0.05
BCST5	AUG 14	93.0	78.9	0.017	<0.005	0.13
BCST5	SEPT 18	86.0	73.9	0.004	<0.005	0.12
AVERAGE =		81.5	70.6	0.011	<0.005	0.10
STANDARD DEV. =		14.3	10.3	0.007		0.04
BCST6	JULY 24	63.0	68.7	0.010	<0.005	0.08
BCST6	AUG 14	87.0	75.9	0.009	<0.005	0.11
BCST6	SEPT 18	78.5	68.9	0.008	<0.005	0.17
AVERAGE =		76.2	71.2	0.009	<0.005	0.12
STANDARD DEV. =		12.2	4.1	0.001		0.05
BIG CREEK STATIONS:	JULY AVERAGE=	70.4	60.6	0.009	<0.005	0.05
BIG CREEK STATIONS:	JULY ST.DEV.=	7.4	4.2	0.002		0.02
BIG CREEK STATIONS:	AUG AVERAGE=	74.7	69.4	0.018	<0.005	0.08
BIG CREEK STATIONS:	AUG ST.DEV.=	12.1	6.3	0.010		0.03
BIG CREEK STATIONS:	SEPT AVERAGE=	73.2	61.6	0.007	<0.005	0.10
BIG CREEK STATIONS:	SEPT ST.DEV.=	7.6	7.8	0.002		0.04

APPENDIX II TABLE 1 BIG CREEK MAINSTEM WATER QUALITY (CONTINUED)

STATION	DATE	DISS. SULPHATE mg/l	T. SULPHATE mg/l	DISS. CHLORIDE mg/l	T. CHLORIDE mg/l	DISSOLVED OXYGEN mg/l
BCST1	JULY 24	8	8	0.7	0.8	9.4
BCST1	AUG 14	9	9	0.5	1.4	10.4
BCST1	SEPT 18	7	6	0.5	0.8	11:3
AVERAGE =		8.0	7.7	0.6	1.0	10.4
STANDARD DEV. =		1.0	1.5	0.1	0.3	0.8
BCST2	JULY 24	9	9	0.6	0.8	10.1
BCST2	AUG 14	10	10	0.5	1.5	10.3
BCST2	SEPT 18	9	8	0.5	0.7	11.2
AVERAGE =		9.3	9.0	0.5	1.0	10.5
STANDARD DEV. =		0.6	1.0	0.1	0.4	0.6
BCST3	JULY 24	9	9	0.6	0.7	9.2
BCST3	AUG 14	11	11	0.5	1.5	9.8
BCST3	SEPT 18	9	8	0.5	0.7	10.8
AVERAGE =		9.7	9.3	0.5	1.0	9.9
STANDARD DEV. =		1.2	1.5	0.1	0.5	0.7
BCST4	JULY 24	10	9	0.7	0.7	9.5
BCST4	AUG 14	13	10	0.6	1.6	10.8
BCST4	SEPT 18	9	8	0.6	0.7	11.1
AVERAGE =		10.7	9.0	0.6	1.0	10.5
STANDARD DEV. =		2.1	1.0	0.1	0.5	0.8
BCST5	JULY 24	10	10	0.6	0.7	9.5
BCST5	AUG 14	11	13	0.8	1.6	11.2
BCST5	SEPT 18	10	9	0.5	0.7	11.8
AVERAGE =		10.3	10.7	0.6	1.0	10.8
STANDARD DEV. =		0.6	2.1	0.2	0.5	1.1
BCST6	JULY 24	10	10	0.6	0.7	10.4
BCST6	AUG 14	13	12	0.9	1.6	11.9
BCST6	SEPT 18	10	9	0.7	0.7	11.7
AVERAGE =		11.0	10.3	0.7	1.0	11.3
STANDARD DEV. =		1.7	1.5	0.2	0.5	0.8
BIG CREEK STATIONS:	JULY	AVERAGE= 9.3	9.2	0.6	0.7	9.7
BIG CREEK STATIONS:	JULY	ST.DEV.= 0.8	0.8	0.1	0.1	0.5
BIG CREEK STATIONS:	AUG	AVERAGE= 11.2	10.8	0.6	1.5	10.7
BIG CREEK STATIONS:	AUG	ST.DEV.= 1.6	1.5	0.2	0.1	0.7
BIG CREEK STATIONS:	SEPT	AVERAGE= 9.0	8.0	0.6	0.7	11.3
BIG CREEK STATIONS:	SEPT	ST.DEV.= 1.1	1.1	0.1	0.04	0.4

APPENDIX II TABLE 7 BIG CREEK Extraction METALS

WATER QUALITY METALS
T=TOTAL, DISS=DISSOLVED METALS mg/l

STATION	DATE	T. Al mg/l	Diss. Al mg/l	T. As mg/l	Diss As mg/l	T. Ba mg/l	Diss. Ba mg/l	T. B mg/l	Diss. B mg/l	T,Ca mg/l	Diss. Ca mg/l
BCST1	JULY 24	0.69	<0.05	<0.05	<0.05	0.073	0.114	0.033	0.005	19.80	12.90
BCST1	AUG 14	<0.05	<0.05	<0.05	<0.05	0.032	0.032	0.005	<0.001	15.30	15.10
BCST1	SEPT 18	0.07	<0.05	<0.05	<0.05	0.038	0.032	0.020	0.030	14.00	12.30
AVERAGE =		0.27	<0.05	<0.05	<0.05	0.048	0.059	0.019	0.012	16.37	13.43
STANDARD DEV. =		0.36				0.022	0.047	0.014	0.016	3.04	1.47
BCST2	JULY 24	1.36	<0.05	<0.05	<0.05	0.066	0.112	0.025	0.004	17.70	14.00
BCST2	AUG 14	<0.05	<0.05	<0.05	<0.05	0.037	0.038	<0.001	<0.001	15.50	15.50
BCST2	SEPT 18	0.11	<0.05	<0.05	<0.05	0.044	0.035	<0.001	<0.001	15.20	13.20
AVERAGE =		0.51	<0.05	<0.05	<0.05	0.049	0.062	0.009	0.002	16.13	14.23
STANDARD DEV. =		0.74				0.015	0.044	0.014	0.002	1.365	1.168
BCST3	JULY 24	0.51	<0.05	<0.05	<0.05	0.049	0.050	0.032	0.006	15.90	13.20
BCST3	AUG 14	0.07	<0.05	<0.05	<0.05	0.042	0.041	0.007	<0.001	15.60	15.00
BCST3	SEPT 18	0.46	<0.05	<0.05	<0.05	0.050	0.037	<0.001	<0.001	15.10	13.00
AVERAGE =		0.35	<0.05	<0.05	<0.05	0.047	0.043	0.013	0.003	15.53	13.73
STANDARD DEV. =		0.24				0.004	0.007	0.016	0.003	0.404	1.102
BCST4	JULY 24	0.74	<0.05	<0.05	<0.05	0.045	0.037	0.023	0.004	14.50	13.70
BCST4	AUG 14	0.23	<0.05	<0.05	<0.05	0.046	0.041	<0.001	<0.001	16.00	15.10
BCST4	SEPT 18	0.19	<0.05	<0.05	<0.05	0.056	0.045	0.003	<0.001	15.40	13.40
AVERAGE =		0.39	<0.05	<0.05	<0.05	0.049	0.041	0.009	0.002	15.30	14.07
STANDARD DEV. =		0.31				0.006	0.004	0.012	0.002	0.755	0.907
BCST5	JULY 24	0.31	0.05	<0.05	<0.05	0.042	0.037	0.015	0.004	14.70	13.70
BCST5	AUG 14	1.33	<0.05	<0.05	<0.05	0.079	0.062	0.018	<0.001	20.50	19.30
BCST5	SEPT 18	0.35	<0.05	<0.05	<0.05	0.086	0.069	0.003	<0.001	19.70	18.00
AVERAGE =		0.66	0.05	<0.05	<0.05	0.069	0.056	0.012	0.002	18.30	17.00
STANDARD DEV. =		0.58				0.024	0.017	0.008	0.002	3.143	2.931
BCST6	JULY 24	<0.05	0.07	<0.05	<0.05	0.067	0.049	0.019	0.006	14.70	16.40
BCST6	AUG 14	1.00	0.05	<0.05	<0.05	0.070	0.055	0.014	<0.001	19.30	18.60
BCST6	SEPT 18	0.31	0.05	<0.05	<0.05	0.062	0.050	0.003	<0.001	17.80	16.50
AVERAGE =		0.45	0.06	<0.05	<0.05	0.066	0.051	0.012	0.003	17.27	17.17
STANDARD DEV. =		0.49	0.01			0.004	0.003	0.008	0.003	2.346	1.242
JULY BIG CR STATION AVERAGE =		0.61	0.05	<0.05	<0.05	0.057	0.067	0.025	0.005	16.22	13.98
JULY BIG CR STATION ST. DEV.=		0.45	0.01			0.013	0.036	0.007	0.001	2.13	1.25
AUG BIG CR STATION AVERAGE =		0.46	0.05	<0.05	<0.05	0.051	0.045	0.008	<0.001	17.03	16.43
AUG BIG CR STATION ST. DEV.=		0.56				0.019	0.011	0.007		2.26	1.97
SEPT BIG CR STATION AVERAGE =		0.25	0.05	<0.05	<0.05	0.056	0.045	0.005	0.006	16.20	14.40
SEPT BIG CR STATION ST. DEV.=		0.15				0.017	0.014	0.007	0.012	2.12	2.29

WATER QUALITY METALS
T=TOTAL;DISS=DISSOLVED METALS mg/l

STATION	DATE	T.Cd mg/l	Diss. Cd mg/l	T. Co mg/l	Diss. Co mg/l	T. Cr mg/l	Diss. Cr mg/l	T. Cu mg/l	Diss. Cu mg/l	T. Fe mg/l	Diss. Fe mg/l
BCST1	JULY 24	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	0.754	0.031
BCST1	AUG 14	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCST1	SEPT 18	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.095	0.026
AVERAGE =		<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	0.285	0.021
STANDARD DEV. =								0.001		0.409	0.014
BCST2	JULY 24	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.015	0.006	1.560	0.028
BCST2	AUG 14	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.050	<0.005
BCST2	SEPT 18	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.057	0.023
AVERAGE =		<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.008	<0.005	0.556	0.019
STANDARD DEV. =								0.006	0.001	0.870	0.012
BCST3	JULY 24	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.008	<0.005	0.679	0.050
BCST3	AUG 14	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.060	<0.005
BCST3	SEPT 18	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.342	0.029
AVERAGE =		<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	0.360	0.028
STANDARD DEV. =								0.002		0.310	0.023
BCST4	JULY 24	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.011	0.008	0.846	0.100
BCST4	AUG 14	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.340	<0.005
BCST4	SEPT 18	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.207	0.039
AVERAGE =		<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.007	0.006	0.464	0.048
STANDARD DEV. =								0.003	0.002	0.337	0.048
BCST5	JULY 24	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.006	0.007	0.689	0.071
BCST5	AUG 14	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	1.360	<0.005
BCST5	SEPT 18	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.246	0.039
AVERAGE =		<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.005	0.006	0.765	0.038
STANDARD DEV. =								0.001	0.001	0.561	0.033
BCST6	JULY 24	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	0.041	0.121
BCST6	AUG 14	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.007	0.011	1.100	<0.005
BCST6	SEPT 18	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	0.014	0.253	0.045
AVERAGE =		<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.006	0.010	0.465	0.057
STANDARD DEV. =								0.001	0.004	0.560	0.059
JULY BIG CR STATION	AVERAGE =	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.009	0.006	0.762	0.067
JULY BIG CR STATION	ST. DEV. =							0.004	0.001	0.485	0.038
AUG BIG CR STATION	AVERAGE =	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.005	0.006	0.486	<0.005
AUG BIG CR STATION	ST. DEV. =							0.001	0.002	0.594	
SEPT BIG CR STATION	AVERAGE =	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	0.200	0.034
SEPT BIG CR STATION	ST. DEV. =								0.004	0.106	0.009

APPENDIX II TABLE 2 BIG CREEK WATERSHED METALS (CONTINUED)

WATER QUALITY METALS
T=TOTAL;DISS=DISSOLVED METALS mg/l

STATION	DATE	Total Hg mg/l	T. Mg mg/l	Diss. Mg mg/l	T. Mn mg/l	Diss. Mn mg/l	T. Mo mg/l	Diss. Mo mg/l	T. Na mg/l	Diss. Na mg/l	T. Ni mg/l
BCST1	JULY 24	<0.00005	4.20	6.20	0.020	0.028	<0.005	<0.005	2.90	4.90	<0.02
BCST1	AUG 14	0.00011	7.10	7.10	0.006	0.005	<0.005	<0.005	5.00	5.60	<0.02
BCST1	SEPT 18	0.00006	7.20	5.90	0.005	0.005	<0.005	<0.005	5.70	4.40	<0.02
AVERAGE =		0.00007	6.17	6.40	0.010	0.013	<0.005	<0.005	4.53	4.97	<0.02
STANDARD DEV. =		0.00003	1.70	0.62	0.008	0.013			1.46	0.60	
BCST2	JULY 24	<0.00005	6.90	6.20	0.020	0.010	<0.005	<0.005	4.20	4.70	<0.02
BCST2	AUG 14	0.00020	7.00	6.60	0.003	0.002	<0.005	<0.005	4.70	5.10	<0.02
BCST2	SEPT 18	0.00006	7.10	5.90	0.004	0.003	<0.005	<0.005	5.00	4.30	<0.02
AVERAGE =		0.00010	7.00	6.23	0.009	0.005	<0.005	<0.005	4.63	4.70	<0.02
STANDARD DEV. =		0.00008	0.10	0.35	0.010	0.004			0.40	0.40	
BCST3	JULY 24	0.00100	6.50	5.80	0.015	0.006	<0.005	<0.005	4.10	4.20	<0.02
BCST3	AUG 14	0.00012	6.80	6.60	0.007	0.005	<0.005	<0.005	4.40	4.80	0.02
BCST3	SEPT 18	0.00007	7.20	5.70	0.008	0.005	<0.005	<0.005	5.40	4.20	<0.02
AVERAGE =		0.00040	6.83	6.03	0.010	0.005	<0.005	<0.005	4.63	4.40	0.02
STANDARD DEV. =		0.00052	0.35	0.49	0.004	0.001			0.68	0.35	
BCST4	JULY 24	<0.00005	6.10	5.90	0.014	0.056	<0.005	<0.005	4.00	4.20	<0.02
BCST4	AUG 14	0.00013	6.90	6.50	0.020	0.019	<0.005	<0.005	4.40	4.80	<0.02
BCST4	SEPT 18	<0.00005	7.30	5.80	0.009	0.015	<0.005	<0.005	5.50	4.10	<0.02
AVERAGE =		0.00008	6.77	6.07	0.014	0.030	<0.005	<0.005	4.63	4.37	<0.02
STANDARD DEV. =		0.00005	0.61	0.38	0.006	0.023			0.78	0.38	
BCST5	JULY 24	0.00005	6.20	5.90	0.012	0.011	<0.005	<0.005	4.10	4.20	<0.02
BCST5	AUG 14	0.00009	8.00	7.50	0.054	0.026	<0.005	<0.005	4.30	4.90	<0.02
BCST5	SEPT 18	0.00006	8.30	7.00	0.011	0.012	<0.005	<0.005	4.90	4.20	<0.02
AVERAGE =		0.00007	7.50	6.80	0.026	0.016	<0.005	<0.005	4.43	4.43	<0.02
STANDARD DEV. =		0.00002	1.14	0.82	0.025	0.008			0.42	0.40	
BCST6	JULY 24	<0.00005	6.30	6.50	0.003	0.016	<0.005	<0.005	4.40	4.30	<0.02
BCST6	AUG 14	0.00020	7.50	7.10	0.044	0.029	<0.005	<0.005	4.00	4.90	<0.02
BCST6	SEPT 18	<0.00005	7.70	6.60	0.010	0.035	<0.005	<0.005	5.10	4.20	<0.02
AVERAGE =		0.00010	7.17	6.73	0.019	0.027	<0.005	<0.005	4.50	4.47	<0.02
STANDARD DEV. =		0.00009	0.76	0.32	0.022	0.010			0.56	0.38	
JULY BIG CR STATION	AVERAGE =	0.00021	6.03	6.08	0.014	0.021	<0.005	<0.005	3.95	4.42	<0.02
JULY BIG CR STATION	ST. DEV. =	0.00039	0.94	0.26	0.006	0.019			0.53	0.31	
AUG BIG CR STATION	AVERAGE =	0.00014	7.22	6.90	0.022	0.014	<0.005	<0.005	4.47	5.02	0.02
AUG BIG CR STATION	ST. DEV. =	0.00005	0.45	0.39	0.022	0.012			0.34	0.31	
SEPT BIG CR STATION	AVERAGE =	0.00006	7.47	6.15	0.008	0.013	<0.005	<0.005	5.27	4.23	<0.02
SEPT BIG CR STATION	ST. DEV. =	0.00001	0.46	0.52	0.003	0.012			0.31	0.10	

APPENDIX II TABLE 2 BIG CREEK MAINSTEM METALS (CONTINUED)

WATER QUALITY METALS
T=TOTAL;DISS=DISSOLVED METALS mg/l

STATION	DATE	Diss. Ni mg/l	T. Pb mg/l	Diss. Pb mg/l	T. Sb mg/l	Diss. Sb mg/l	T. Se mg/l	Diss. Se mg/l	T. Si mg/l	Diss. Si mg/l	T. Sn mg/l
BCST1	JULY 24	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	7.50	6.00	<0.01
BCST1	AUG 14	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	5.50	5.80	<0.01
BCST1	SEPT 18	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	6.10	5.50	<0.01
AVERAGE =		<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	6.37	5.77	<0.01
STANDARD DEV. =									1.03	0.25	
BCST2	JULY 24	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	7.60	6.20	<0.01
BCST2	AUG 14	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	5.50	5.80	<0.01
BCST2	SEPT 18	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	6.20	5.50	<0.01
AVERAGE =		<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	6.43	5.83	<0.01
STANDARD DEV. =									1.07	0.35	
BCST3	JULY 24	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	6.30	8.40	<0.01
BCST3	AUG 14	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	5.50	5.50	<0.01
BCST3	SEPT 18	<0.02	<0.02	0.04	<0.05	<0.05	<0.05	<0.05	6.90	5.40	<0.01
AVERAGE =		<0.02	<0.02	0.03	<0.05	<0.05	<0.05	<0.05	6.23	6.43	<0.01
STANDARD DEV. =				0.01					0.70	1.70	
BCST4	JULY 24	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	6.60	6.10	<0.01
BCST4	AUG 14	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	5.90	5.70	<0.01
BCST4	SEPT 18	<0.02	<0.02	0.08	<0.05	<0.05	<0.05	<0.05	6.60	5.50	<0.01
AVERAGE =		<0.02	<0.02	0.04	<0.05	<0.05	<0.05	<0.05	6.37	5.77	<0.01
STANDARD DEV. =				0.03					0.40	0.31	
BCST5	JULY 24	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	6.10	6.00	<0.01
BCST5	AUG 14	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	7.90	5.70	<0.01
BCST5	SEPT 18	<0.02	<0.02	0.06	<0.05	<0.05	<0.05	<0.05	6.40	5.30	<0.01
AVERAGE =		<0.02	<0.02	0.03	<0.05	<0.05	<0.05	<0.05	6.80	5.67	<0.01
STANDARD DEV. =				0.02					0.96	0.35	
BCST6	JULY 24	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	5.70	5.90	<0.01
BCST6	AUG 14	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	7.30	5.80	<0.01
BCST6	SEPT 18	<0.02	<0.02	0.06	<0.05	<0.05	<0.05	<0.05	6.50	5.60	<0.01
AVERAGE =		<0.02	<0.02	0.03	<0.05	<0.05	<0.05	<0.05	6.50	5.77	<0.01
STANDARD DEV. =				0.02					0.80	0.15	
JULY BIG CR STATION	AVERAGE =	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	6.63	6.43	<0.01
JULY BIG CR STATION	ST. DEV.=								0.77	0.97	
AUG BIG CR STATION	AVERAGE =	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	6.27	5.72	<0.01
AUG BIG CR STATION	ST. DEV.=								1.06	0.12	
SEPT BIG CR STATION	AVERAGE =	<0.02	<0.02	0.05	<0.05	<0.05	<0.05	<0.05	6.45	5.47	<0.01
SEPT BIG CR STATION	ST. DEV.=			0.02					0.29	0.10	

APPENDIX II TABLE

WATER QUALITY METALS
T=TOTAL; DISS=DISSOLVED METALS mg/l

STATION	DATE	Diss. Sn mg/l	T. Sr mg/l	Diss. Sr mg/l	T. Ti mg/l	Diss. Ti mg/l	T. V mg/l	Diss. V mg/l	T. Zn mg/l	Diss. Zn mg/l
BCBT1	JULY 24	<0.01	0.226	0.155	0.032	<0.002	<0.01	<0.01	0.023	0.026
BCBT1	AUG 14	<0.01	0.175	0.173	<0.002	<0.002	<0.01	<0.01	<0.002	0.017
BCBT1	SEPT 18	0.21	0.169	0.141	0.004	<0.002	<0.01	<0.01	0.008	0.035
AVERAGE =		0.08	0.190	0.156	0.013	<0.002	<0.01	<0.01	0.011	0.026
STANDARD DEV. =		0.12	0.031	0.016	0.017				0.011	0.009
BCBT2	JULY 24	<0.01	0.200	0.177	0.030	<0.002	<0.01	<0.01	0.365	0.028
BCBT2	AUG 14	<0.01	0.176	0.191	<0.002	<0.002	<0.01	<0.01	<0.002	0.008
BCBT2	SEPT 18	0.24	0.189	0.158	0.006	<0.002	<0.01	<0.01	0.011	0.025
AVERAGE =		0.09	0.188	0.175	0.013	<0.002	<0.01	<0.01	0.126	0.020
STANDARD DEV. =		0.13	0.012	0.017	0.015				0.207	0.011
BCBT3	JULY 24	<0.01	0.176	0.155	0.016	<0.002	<0.01	<0.01	0.015	0.022
BCBT3	AUG 14	<0.01	0.174	0.172	<0.002	<0.002	<0.01	<0.01	<0.002	0.042
BCBT3	SEPT 18	0.15	0.181	0.148	0.018	<0.002	<0.01	<0.01	0.010	0.029
AVERAGE =		0.06	0.177	0.158	0.012	<0.002	<0.01	<0.01	0.009	0.031
STANDARD DEV. =		0.08	0.004	0.012	0.009				0.007	0.010
BCBT4	JULY 24	<0.01	0.160	0.153	0.020	0.003	<0.01	<0.01	0.017	0.015
BCBT4	AUG 14	<0.01	0.172	0.168	0.009	<0.002	<0.01	<0.01	<0.002	0.011
BCBT4	SEPT 18	0.21	0.183	0.148	0.011	<0.002	<0.01	<0.01	0.009	0.025
AVERAGE =		0.08	0.172	0.156	0.013	0.002	<0.01	<0.01	0.009	0.017
STANDARD DEV. =		0.12	0.012	0.010	0.006	0.001			0.008	0.007
BCBT5	JULY 24	<0.01	0.166	0.152	0.017	<0.002	<0.01	<0.01	0.053	0.021
BCBT5	AUG 14	<0.01	0.217	0.214	0.041	<0.002	<0.01	<0.01	<0.002	0.025
BCBT5	SEPT 18	0.08	0.228	0.199	0.011	<0.002	<0.01	<0.01	0.022	0.037
AVERAGE =		0.03	0.204	0.188	0.023	<0.002	<0.01	<0.01	0.026	0.028
STANDARD DEV. =		0.04	0.033	0.032	0.016				0.026	0.008
BCBT6	JULY 24	<0.01	0.174	0.183	0.004	<0.002	<0.01	<0.01	0.019	0.138
BCBT6	AUG 14	<0.01	0.205	0.205	0.034	<0.002	<0.01	<0.01	0.025	0.027
BCBT6	SEPT 18	0.16	0.205	0.177	0.010	<0.002	<0.01	<0.01	0.007	0.133
AVERAGE =		0.06	0.195	0.188	0.016	<0.002	<0.01	<0.01	0.017	0.099
STANDARD DEV. =		0.09	0.018	0.015	0.016				0.009	0.063
JULY BIG CR STATION	AVERAGE =	<0.01	0.184	0.163	0.020	0.002	<0.01	<0.01	0.082	0.042
JULY BIG CR STATION	ST. DEV.=		0.025	0.014	0.010	0.0004			0.139	0.047
AUG BIG CR STATION	AVERAGE =	<0.01	0.187	0.187	0.015	<0.002	<0.01	<0.01	0.006	0.022
AUG BIG CR STATION	ST. DEV.=		0.019	0.019	0.018				0.009	0.012
SEPT BIG CR STATION	AVERAGE =	0.18	0.193	0.162	0.010	<0.002	<0.01	<0.01	0.011	0.047
SEPT BIG CR STATION	ST. DEV.=	0.06	0.021	0.022	0.005				0.005	0.042

APPENDIX II TABLE 3 STODDART CREEK WATER QUALITY

STATION	DATE 1984	TIME	FLOW cms	TEMP. C	pH UNITS	CONDUCTIVITY umhos/cm	TURBIDITY F.T.U.	N.F.R. mg/l	F.R. mg/l	T. ALKALINITY mg/l CaCO
STODDART	JULY 24	1056	0.310	9.1	7.3	141	2.9	23	125	52.0
STODDART	AUG 14	1118	0.639	3.3	7.3	131	2.9	33	129	46.5
STODDART	SEPT 18	1018	0.634	0.8	7.4	119	0.1	<5.0	107	40.0
AVERAGE =			0.528	4.4	7.3	130	2.0	28.0	120.3	46.2
STANDARD DEV. =			0.189	4.3	0.1	11	1.6	7.1	11.7	6.0

STATION	DATE	T. HARDNESS mg/l CaCO	DISS. HARDNESS mg/l CaCO	DISS. PHOSPHATE mg/l	DISS. NITRITE mg/l	DISS. NITRATE mg/l
STODDART	JULY 24	60.9	63.7	0.012	<0.005	0.07
STODDART	AUG 14	69.2	61.0	0.006	<0.005	0.01
STODDART	SEPT 18	61.8	52.3	0.008	<0.005	0.13
AVERAGE =		64.0	59.0	0.009	<0.005	0.07
STANDARD DEV. =		4.6	6.0	0.003		0.06

STATION	DATE	DISS. SULPHATE mg/l	T. SULPHATE mg/l	DISS. CHLORIDE mg/l	T. CHLORIDE mg/l	DISSOLVED OXYGEN mg/l
STODDART	JULY 24	17	16	0.8	0.9	10.2
STODDART	AUG 14	16	15	1.2	1.6	11.7
STODDART	SEPT 18	13	12	0.7	0.9	12.0
AVERAGE =		15.3	14.3	0.9	1.1	11.3
STANDARD DEV. =		2.1	2.1	0.3	0.4	1.0

APPENDIX II TABLE 4 STODDART CREEK METALS

WATER QUALITY METALS
T=TOTAL;DISS=DISSOLVED METALS mg/l

STATION	DATE	T. Al mg/l	Diss. Al mg/l	T. As mg/l	Diss As mg/l	T. Ba mg/l	Diss. Ba mg/l	T. B mg/l	Diss. B mg/l	T.Ca mg/l	Diss. Ca mg/l
STODDART 1	JULY 24	<0.05	0.07	<0.05	<0.05	0.061	0.061	0.015	0.006	13.80	18.50
STODDART 1	AUG 14	0.92	0.07	<0.05	<0.05	0.074	0.060	<0.001	<0.001	18.80	18.00
STODDART 1	SEPT 18	0.34	0.08	<0.05	<0.05	0.071	0.054	0.003	0.020	17.30	15.30
AVERAGE =		0.44	0.07	<0.05	<0.05	0.069	0.058	0.006	0.009	16.63	17.27
STANDARD DEV. =		0.44	0.01			0.007	0.004	0.008	0.010	2.566	1.721

WATER QUALITY METALS

STATION	DATE	T.Cd mg/l	Diss. Cd mg/l	T. Co mg/l	Diss. Co mg/l	T. Cr mg/l	Diss. Cr mg/l	T. Cu mg/l	Diss. Cu mg/l	T. Fe mg/l	Diss. Fe mg/l
STODDART 1	JULY 24	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.044	0.007	0.101	0.096
STODDART 1	AUG 14	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.837	<0.005
STODDART 1	SEPT 18	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	0.341	0.082
AVERAGE =		<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	0.018	0.006	0.426	0.061
STANDARD DEV. =								0.023	0.001	0.375	0.049

WATER QUALITY METALS

STATION	DATE	Total Hg mg/l	T. Mg mg/l	Diss. Mg mg/l	T. Mn mg/l	Diss. Mn mg/l	T. Mo mg/l	Diss. Mo mg/l	T. Na mg/l	Diss. Na mg/l	T. Ni mg/l
STODDART 1	JULY 24	0.00005	6.20	4.00	0.004	0.022	<0.005	<0.005	4.40	3.00	<0.02
STODDART 1	AUG 14	0.00010	4.00	3.80	0.024	0.016	<0.005	<0.005	2.60	2.90	<0.02
STODDART 1	SEPT 18	<0.00005	3.80	3.20	0.012	0.009	0.007	<0.005	3.10	2.50	<0.02
AVERAGE =		0.00007	4.67	3.67	0.013	0.016	0.006	<0.005	3.37	2.80	<0.02
STANDARD DEV. =		0.00003	1.33	0.42	0.010	0.007	0.001		0.93	0.26	

APPENDIX II TABLE 4 STODDART CREEK METALS (CONTINUED)

WATER QUALITY METALS
T=TOTAL;DISS=DISSOLVED METALS ug/ml

STATION	DATE	Diss. Ni mg/l	T. Pb mg/l	Diss. Pb mg/l	T. Sb mg/l	Diss. Sb mg/l	T. Se mg/l	Diss. Se mg/l	T. Si mg/l	Diss. Si mg/l	T. Sn mg/l
STODDART 1	JULY 24	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	5.50	6.70	<0.01
STODDART 1	AUG 14	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	8.60	7.30	<0.01
STODDART 1	SEPT 18	<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	8.30	7.00	0.03
AVERAGE =		<0.02	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	7.47	7.00	0.02
STANDARD DEV. =									1.71	0.30	0.01

WATER QUALITY METALS

STATION	DATE	Diss. Sn mg/l	T. Sr mg/l	Diss. Sr mg/l	T. Ti mg/l	Diss. Ti mg/l	T. V mg/l	Diss. V mg/l	T. Zn mg/l	Diss. Zn mg/l
STODDART 1	JULY 24	<0.01	0.157	0.212	0.003	0.002	<0.01	<0.01	0.015	0.031
STODDART 1	AUG 14	<0.01	0.204	0.200	0.031	<0.002	<0.01	<0.01	<0.002	0.021
STODDART 1	SEPT 18	0.17	0.204	0.169	0.014	<0.002	<0.01	<0.01	0.022	0.034
AVERAGE =		0.06	0.188	0.194	0.016	0.002	<0.01	<0.01	0.013	0.029
STANDARD DEV. =		0.09	0.027	0.022	0.014				0.010	0.007

APPENDIX III

AUTOMATIC SAMPLER WATER QUALITY DATA

APPENDIX III TABLE 1 AUTOMATIC SAMPLER WATER QUALITY - JULY

AUTOMATIC SAMPLER # 1 MONTH: JULY
LOCATION: SEYMOUR CREEK

SAMPLE #		TIME	NFR mg/l	pH UNITS	TURBIDITY F.T.U.	CONDUCTIVITY umhos/cm
1	JULY 24	1200	5	7.4	2.9	206
2		1300	<5	7.8	1.6	210
3		1400	<5	7.9	1.3	210
4		1500	<5	8.0	5.0	210
5		1600	12	7.9	11.1	210
6		1700	21	7.9	15.0	204
7		1800	30	7.8	21.0	206
8		1900	30	7.9	23.5	208
9		2000	33	7.8	26.5	209
10		2100	44	7.8	27.0	211
11		2200	35	7.8	27.0	208
12		2300	28	7.8	24.0	208
13		2400	36	7.9	24.0	208
14	JULY 25	100	33	7.8	24.0	210
15		200	38	7.8	24.0	210
16		300	47	7.8	24.0	210
17		400	43	7.9	28.0	210
18		500	43	7.7	32.0	210
19		600	43	7.8	28.0	210
20		700	19	7.9	16.0	210
21		800	14	7.7	8.0	210
22		900	9	7.9	8.0	210
23		1000	5	7.7	3.2	210
24		1100	<5	7.8	3.2	210
25		1200	5	7.8	2.0	210
26		1300	<5	7.8	2.0	210
	AVERAGE =		23.0	7.8	15.9	209.2
	ST. DEV. =		15.6	0.1	10.7	1.6
	MAX =		47.0	8.0	32.0	211
	MIN =		<5.0	7.4	1.3	204

APPENDIX III TABLE 1 AUTOMATIC SAMPLER WATER QUALITY - JULY (CONTINUED)

AUTOMATIC SAMPLER # 2 MONTH: JULY
LOCATION: BCST5

SAMPLE #		TIME	NFR mg/l	pH UNITS	TURBIDITY F.T.U.	CONDUCTIVITY umhos/cm
1	JULY 24	1230	15	7.5	3.5	166
2		1330	13	7.8	6.2	166
3		1430	9	7.8	3.5	166
4		1530	11	7.7	6.2	163
5		1630	13	7.8	9.0	162
6		1730	15	7.7	10.8	162
7		1830	17	7.8	12.0	166
8		1930	19	7.7	13.5	166
9		2030	20	7.7	13.0	163
10		2130	22	7.9	14.0	166
11		2230	24	7.9	15.0	162
12		2330	22	7.7	13.5	166
13		2430	22	7.7	13.0	166
14	JULY 25	130	20	7.8	12.5	166
15		230	26	7.8	16.5	166
16		330	24	7.8	15.0	166
17		430	17	7.7	16.5	167
18		530	25	7.8	17.0	167
19		630	14	7.6	13.0	167
20		730	14	7.8	7.0	167
21		830	12	7.7	6.0	167
22		930	9	7.8	4.0	170
23		1030	10	7.7	3.0	167
24		1130	11	7.8	2.5	169
25		1230	8	7.7	2.5	167
26		1330	11	7.9	2.5	167
		AVERAGE =	16.3	7.8	9.7	165.9
		ST. DEV. =	5.6	0.1	5.1	2.0
		MAX =	26.0	7.9	17.0	170.0
		MIN =	8.0	7.5	2.5	162.0

APPENDIX III TABLE 1 AUTOMATIC SAMPLER WATER QUALITY - JULY (CONTINUED)

AUTOMATIC SAMPLER # 3 MONTH: JULY
LOCATION: REVENUE CREEK

SAMPLE #		TIME	NFR mg/l	pH UNITS	TURBIDITY F.T.U.	CONDUCTIVITY umhos/cm
1	JULY 24	1445	11	6.9	3.8	133
2		1545	14	7.4	7.5	132
3		1645	16	7.4	6.5	132
4		1745	6	7.4	1.1	132
5		1845	9	7.4	1.4	132
6		1945	8	7.4	1.1	132
7		2045	12	7.3	1.8	132
8		2145	8	7.4	1.8	132
9		2245	7	7.4	1.6	132
10		2345	6	7.4	1.8	132
11		2445	7	7.5	1.8	132
12	JULY 25	145	5	7.5	3.1	132
13		245	12	7.4	3.1	132
14		100	8	7.4	3.1	132
15		445	5	7.4	2.0	132
16		545	7	7.6	3.1	132
17		645	8	7.3	1.8	132
18		745	8	7.4	2.7	132
19		845	7	7.4	1.3	132
20		945	5	7.4	1.3	133
21		1045	5	7.4	1.3	132
22		1145	12	7.4	1.3	132
23		1245	16	7.4	1.3	132
24		1345	11	7.6	2.9	135
25		1445	9	7.5	2.0	135
26		1545	10	7.5	2.2	132
	AVERAGE =		8.9	7.4	2.4	132.3
	ST. DEV. =		3.2	0.1	1.6	0.8
	MAX =		16.0	7.6	6.5	135.0
	MIN =		5.0	6.9	1.1	132.0

APPENDIX III TABLE 1 AUTOMATIC SAMPLER WATER QUALITY - JULY (CONTINUED)

AUTOMATIC SAMPLER # 4 MONTH: JULY
LOCATION: BCST3

SAMPLE #		TIME	NFR mg/l	pH UNITS	TURBIDITY F.T.U.	CONDUCTIVITY umhos/cm
1	JULY 24	1515	<5	7.6	2.7	134
2		1615	5	7.5	2.7	134
3		1715	5	7.5	0.7	133
4		1815	7	7.6	2.2	134
5		1915	<5	7.6	0.6	134
6		2015	<5	7.5	1.8	134
7		2115	<5	7.6	7.4	132
8		2215	<5	7.7	1.0	134
9		2315	6	7.6	0.8	133
10		2415	<5	7.7	1.0	134
11	JULY 25	115	<5	7.7	0.3	133
12		215	<5	7.5	0.3	134
13		315	<5	7.7	0.3	134
14		415	<5	7.6	0.3	134
15		515	5	7.7	0.3	134
16		615	<5	7.8	0.2	134
17		715	<5	7.7	0.2	134
18		815	5	7.8	0.2	134
19		915	5	7.7	0.3	134
20		1015	<5	7.7	0.3	134
21		1115	<5	7.7	0.1	134
22		1215	<5	7.6	0.1	134
23		1315	<5	7.5	0.1	134
24		1415	<5	7.5	0.1	134
25		1515	<5	7.6	0.5	134
26		1615	5	7.7	0.2	134
		AVERAGE =	5.1	7.6	1.0	133.8
		ST. DEV. =	0.4	0.1	1.5	0.5
		MAX =	7.0	7.8	7.4	134.0
		MIN =	<5	7.5	0.1	132.0

APPENDIX III TABLE 2 AUTOMATIC SAMPLER WATER QUALITY - AUGUST

AUTOMATIC SAMPLER # 1 MONTH: AUGUST
LOCATION: SEYMOUR CREEK

SAMPLE #		TIME	NFR mg/l	pH UNITS	TURBIDITY F.T.U.	CONDUCTIVITY umhos/cm
1	AUG 14	1135	48	7.2	18.0	222
2		1235	47	7.6	18.0	222
3		1335	43	7.6	15.0	219
4		1435	39	7.6	14.0	219
5		1535	46	7.7	16.0	219
6		1635	43	7.7	14.0	219
7		1735	46	7.7	13.0	219
8		1835	38	7.7	13.0	219
9		1935	34	7.7	15.0	221
10		2035	48	7.6	14.0	220
11		2135	32	7.7	12.0	219
12		2235	40	7.8	12.0	222
13		2335	40	7.7	12.0	220
14		2435	47	7.7	12.0	220
15	AUG 15	135	43	7.7	13.0	221
16		235	37	7.7	13.5	222
17		335	41	7.7	12.5	222
18		435	29	7.7	13.0	222
19		535	33	7.7	12.5	221
20		635	28	7.7	11.0	222
21		735	31	7.7	11.0	220
22		835	26	7.8	11.0	220
23		935	36	7.8	11.0	222
24		1035	27	7.7	11.0	222
25		1135	17	7.7	8.5	221
26		1235	20	7.7	9.0	222
27		1335	21	7.7	8.5	222
		AVERAGE =	36.3	7.7	12.7	220.7
		ST. DEV. =	9.1	0.1	2.4	1.3
		MAX =	48.0	7.8	18.0	222.0
		MIN =	20.0	7.2	8.5	219.0

APPENDIX III TABLE 2 AUTOMATIC SAMPLER WATER QUALITY - AUGUST (CONTINUED)

AUTOMATIC SAMPLER # 2 MONTH: AUGUST
LOCATION: BCSTS

SAMPLE #		TIME	NFR mg/l	pH UNITS	TURBIDITY F.T.U.	CONDUCTIVITY umhos/cm
1	AUG 14	1145	43	7.4	24.0	182
2		1245	20	7.6	8.5	180
3		1345	19	7.6	7.6	181
4		1445	19	7.8	7.5	191
5		1545	18	7.9	8.0	188
6		1645	20	8.0	11.0	189
7		1745	17	7.5	7.5	182
8		1845	10	7.9	8.0	182
9		1945	20	7.9	11.0	190
10		2045	16	7.9	9.0	194
11		2145	22	7.9	8.3	190
12		2245	48	7.9	23.0	191
13		2345	37	7.9	18.5	194
14		2445	29	7.8	16.5	181
15	AUG 15	145	24	7.8	14.0	181
16		245	25	7.9	11.0	181
17		345	15	7.8	9.0	181
18		445	25	8.0	14.0	189
19		545	18	8.0	8.0	182
20		645	15	7.7	7.5	182
21		745	12	7.7	6.8	179
22		845	8	7.8	6.8	180
23		945	17	7.8	6.8	180
24		1045	13	7.8	5.0	189
25		1145	20	7.9	5.0	189
26		1245	12	7.7	6.0	181
27		1345	15	7.9	3.8	182
	AVERAGE =		20.6	7.8	10.1	184.9
	ST. DEV. =		9.4	0.1	5.2	4.9
	MAX =		48.0	8.0	24.0	194.0
	MIN =		8.0	7.4	5.0	179.0

APPENDIX III TABLE 2 AUTOMATIC SAMPLER WATER QUALITY - AUGUST (CONTINUED)

AUTOMATIC SAMPLER # 3 MONTH: AUGUST
LOCATION: REVENUE CREEK

SAMPLE #		TIME	NFR mg/l	pH UNITS	TURBIDITY F.T.U.	CONDUCTIVITY umhos/cm
1	AUG 14	1735	153	7.9	88.0	156
2		1835	97	7.7	56.0	153
3		1935	56	8.0	37.0	177
4		2035	30	7.4	17.0	151
5		2135	8	7.4	7.0	154
6		2235	7	7.4	7.0	154
7		2335	8	7.4	7.6	150
8		2435	6	7.4	5.0	150
9	AUG 15	135	8	7.3	6.0	150
10		235	5	7.3	6.8	150
11		335	<5	7.4	5.4	150
12		435	<5	7.4	5.3	154
13		535	<5	7.3	5.0	151
14		635	6	7.3	4.0	152
15		735	<5	7.6	3.0	166
16		835	<5	7.4	2.5	153
17		935	<5	7.7	1.7	166
18		1035	<5	7.6	1.5	152
19		1135	<5	7.3	1.1	152
20		1235	<5	7.5	1.8	153
21		1335	<5	7.4	5.3	152
22		1435	12	7.2	5.3	152
23		1535	9	7.3	4.0	152
24		1635	10	7.4	4.0	152
25		1735	<5	7.4	2.9	152
26		1835	6	7.7	1.5	163
	AVERAGE =		18.3	7.5	11.2	154.5
	ST. DEV. =		34.1	0.2	19.7	6.4
	MAX =		153.0	8.0	88.0	177.0
	MIN =		5.0	7.2	1.1	150.0

APPENDIX III TABLE 2 AUTOMATIC SAMPLER WATER QUALITY AUGUST (CONTINUED)

AUTOMATIC SAMPLER # 4 MONTH: AUGUST
LOCATION: RCBT3

SAMPLE #		TIME	NFR mg/l	pH UNITS	TURBIDITY F.T.U	CONDUCTIVITY umhos/cm
1	AUG 14	1635	7	7.2	1.5	150
2		1735	<5	7.6	1.9	150
3		1835	<5	7.3	1.8	149
4		1935	<5	7.3	1.6	149
5		2035	<5	7.2	1.6	150
6		2135	<5	7.8	1.8	149
7		2235	<5	7.3	1.3	150
8		2335	<5	7.3	1.5	150
9		2435	<5	7.3	1.5	150
10	AUG 15	135	<5	7.3	1.8	151
11		235	<5	7.3	2.2	151
12		335	<5	7.5	1.4	151
13		435	<5	7.2	1.5	150
14		535	<5	7.9	1.5	150
15		635	<5	7.3	1.8	152
16		735	<5	7.3	1.6	151
17		835	<5	7.8	2.8	170
18		935	<5	7.7	1.5	162
19		1035	<5	7.6	1.4	150
20		1135	<5	7.4	1.5	153
21		1235	<5	7.4	1.6	150
22		1335	<5	7.3	1.5	149
23		1435	<5	7.4	1.6	150
24		1535	<5	7.3	1.4	150
25		1635	<5	7.3	1.5	151
26		1735	<5	7.5	1.4	151
27		1835	<5	7.4	1.4	152
	AVERAGE =		5.0	7.4	1.6	151.5
	ST. DEV. =			0.2	0.3	4.4
	MAX =		7.0	7.9	2.8	170.0
	MIN =		<5.0	7.2	1.3	149.0

APPENDIX III TABLE 3 AUTOMATIC SAMPLER WATER QUALITY - SEPTEMBER

AUTOMATIC SAMPLER # 1 MONTH: SEPTEMBER
LOCATION: SEYMOUR CREEK

SAMPLE #		TIME	NFR mg/l	pH UNITS	TURBIDITY F.T.U.	CONDUCTIVITY umhos/cm
1	SEPT 18	1105	8	7.7	0.5	213
2		1205	6	7.7	0.7	216
3		1305	<5	7.8	0.5	216
4		1405	<5	7.7	0.6	216
5		1505	<5	7.7	1.3	216
6		1605	6	7.7	0.8	213
7		1705	8	7.8	0.8	216
8		1805	<5	7.8	0.6	216
9		1905	<5	7.8	0.8	216
10		2005	12	7.8	2.7	216
11		2105	25	7.7	10.0	210
12		2205	10	7.7	4.6	210
13		2305	7	7.8	1.6	212
14		2405	<5	7.7	1.5	212
15	SEPT 19	105	<5	7.8	1.1	212
16		205	5	7.7	1.0	214
17		305	<5	7.8	0.8	213
18		405	<5	7.8	0.8	213
19		505	<5	7.9	0.8	213
20		605	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE
21		705	<5	8.1	2.5	223
22		805	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE
23		905	<5	8.2	1.1	232
		AVERAGE =	7.0	7.8	1.7	215.1
		ST. DEV. =	4.5	0.1	2.1	4.8
		MAX =	25.0	8.2	10.0	232.0
		MIN =	5.0	7.7	0.5	210.0

APPENDIX III TABLE 3 AUTOMATIC SAMPLER WATER QUALITY - SEPTEMBER (CONTINUED)

AUTOMATIC SAMPLER # 2 MONTH: SEPTEMBER
LOCATION: BCST5

SAMPLE #	TIME	NFR mg/l	pH UNITS	TURBIDITY F.T.U.	CONDUCTIVITY umhos/cm
1 SEPT 18	1120	22	8.0	4.5	183
2	1220	<5	7.6	0.3	177
3	1320	<5	7.8	0.3	175
4	1420	<5	7.9	0.3	177
5	1520	5	7.5	0.3	178
6	1620	<5	7.2	1.0	178
7	1720	<5	7.7	0.5	178
8	1820	<5	7.6	0.4	178
9	1920	7	7.6	1.1	177
10	2020	12	7.6	3.5	177
11	2120	13	7.6	4.5	173
12	2220	6	7.7	1.0	173
13	2320	5	7.7	0.3	176
14	2420	<5	7.6	0.3	177
15 SEPT 19	120	7	7.6	0.8	179
16	220	<5	7.6	0.7	179
17	320	5	7.6	0.5	178
18	420	<5	7.9	0.4	184
19	520	<5	7.5	0.3	184
20	620	7	7.7	0.3	178
21	720	7	7.8	1.0	187
22	820	<5	7.7	0.3	182
23	920	<5	8.0	1.0	187
24	1020	<5	7.6	0.7	184
AVERAGE =		6.7	7.7	1.0	179.1
ST. DEV. =		3.9	0.2	1.3	3.9
MAX =		22.0	8.0	4.5	187.0
MIN =		5.0	7.2	0.3	173.0

APPENDIX III TABLE 3 AUTOMATIC SAMPLER WATER QUALITY - SEPTEMBER (CONTINUED)

AUTOMATIC SAMPLER # 3 MONTH: SEPTEMBER
LOCATION: REVENUE CREEK

SAMPLE #		TIME	NFR mg/l	pH UNITS	TURBIDITY F.T.U.	CONDUCTIVITY umhos/cm
1	SEPT 18	1250	12	7.1	6.5	190
2		1350	18	7.6	10.0	209
3		1450	9	7.1	6.5	192
4		1550	3730	6.8	2800.0	189
5		1650	526	7.6	300.0	224
6		1750	118	7.3	27.0	197
7		1850	77	7.1	22.0	196
8		1950	73	7.6	18.0	217
9		2050	539	7.0	200.0	196
10		2150	99	7.1	19.0	197
11		2250	50	7.1	15.0	193
12		2350	56	7.1	15.0	193
13		2450	45	7.1	13.5	193
14	SEPT 19	150	36	7.1	13.0	192
15		250	38	7.6	30.0	196
16		350	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE
17		450	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE
18		550	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE
19		650	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE
20		750	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE
21		850	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE
22		950	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE
23		1050	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE
24		1150	90	7.1	21.0	214
25		1250	144	7.7	27.0	224
26		1350	186	7.1	33.0	191
	AVERAGE =		324.8	7.2	198.7	200.2
	ST. DEV. =		864.0	0.3	653.7	11.8
	MAX =		3730.0	7.7	2800.0	224.0
	MIN =		9.0	6.8	6.5	189.0

APPENDIX III TABLE 3 AUTOMATIC SAMPLER WATER QUALITY - SEPTEMBER (CONTINUED)

AUTOMATIC SAMPLER # 4 MONTH: SEPTEMBER
LOCATION: BC3T3

SAMPLE #		TIME	NFR mg/l	pH UNITS	TURBIDITY F.T.U.	CONDUCTIVITY umhos/cm
1	SEPT 18	1305	<5	7.4	<0.1	135
2		1405	<5	7.5	<0.1	139
3		1505	<5	7.7	<0.1	139
4		1605	<5	7.6	<0.1	139
5		1705	9	7.6	1.8	139
6		1805	<5	7.6	<0.1	139
7		1905	<5	7.6	<0.1	140
8		2005	<5	7.6	<0.1	140
9		2105	<5	7.5	<0.1	140
10		2205	<5	7.7	<0.1	140
11		2305	<5	7.7	<0.1	139
12		2405	<5	7.7	0.1	140
13	SEPT 19	105	<5	7.5	<0.1	141
14		205	<5	7.6	0.1	141
15		305	<5	7.5	0.1	141
16		405	<5	7.5	0.2	141
17		505	<5	7.7	0.1	141
18		605	<5	7.6	0.1	141
19		705	<5	7.7	0.2	141
20		805	<5	7.6	0.1	141
21		905	<5	7.6	<0.1	141
22		1005	<5	7.6	<0.1	141
23		1105	<5	7.5	0.1	141
24		1205	<5	7.4	0.1	141
	AVERAGE =		5.2	7.6	0.2	140.0
	ST. DEV. =		0.8	0.1	0.3	1.4
	MAX =		9.0	7.7	1.8	141.0
	MIN =		5.0	7.4	0.1	135.0

APPENDIX IV

SYSTEM REPLICATE WATER QUALITY DATA

APPENDIX IV TABLE 1 SYSTEM [illegible] WATER QUALITY ... JULY

STATION	DATE	FLOW cms	NFR LEFT mg/l	NFR CENTER mg/l	NFR RIGHT mg/l	NFR AVERAGE mg/l	NFR ST. DEV. mg/l
BCST1	JULY 24	1.823	<5	<5	8	6.0	1.7
TRIBUTARY A	JULY 24	0.040	45	5	10	20.0	21.8
HERBERT CREEK	JULY 24	0.006	5		5	5.0	
MAGMAN CREEK	JULY 24	0.073	5	5	5	5.0	
BCST2	JULY 24	1.890	6	5	5	5.3	0.6
NONAME CREEK	JULY 24	0.014	6		9	7.5	2.1
MECHANIC CREEK	JULY 24	0.014	630	5290	622	2180.6	2692.8
BCST3	JULY 24	1.751	7	7	7	7.0	
BCST3	JULY 25		7	14	12	11.0	3.6
REVENUE CREEK	JULY 24	0.189	18	14	37	23.0	12.3
REVENUE CREEK	JULY 25		10	20	32	20.7	11.0
BOLIDEN CREEK	JULY 24	0.0005	228		236	232.0	5.7
HAPPY CREEK	JULY 24	0.001	8		12	10.0	2.8
TARA CREEK	JULY 24	0.001	19		9	14.0	7.1
TRIBUTARY B	JULY 24						
BCST4	JULY 24	2.334	14	12	14	13.3	1.2
SEYMOUR CREEK	JULY 24	0.865	10	9	6	8.3	2.1
SEYMOUR CREEK	JULY 25		8	7	10	8.3	1.5
BCST5	JULY 24	3.295	15	10	15	13.3	2.9
BCST5	JULY 25		9	7	8	8.0	1.0
STODDART CREEK	JULY 24	0.310	20	17	19	18.7	1.5
BCST6	JULY 24	3.814	20	21	18	19.7	1.5

APPENDIX IV TABLE 1 SYSTEM REPLICATE WATER QUALITY DATA - JULY (CONTINUED)

STATION	DATE	pH LEFT UNITS	pH CENTER UNITS	pH RIGHT UNITS	pH AVERAGE UNITS	pH ST. DEV. UNITS
BCST1	JULY 24	7.4	7.4	7.6	7.5	0.1
TRIBUTARY A	JULY 24	7.7	7.7	7.7	7.7	
BERBESS CREEK	JULY 24	7.2		7.2	7.2	
MAGMAN CREEK	JULY 24	7.6	7.6	7.6	7.6	
BCST2	JULY 24	7.3	7.3	7.4	7.3	0.1
NONAME CREEK	JULY 24	7.2		7.3	7.3	0.1
MECHANIC CREEK	JULY 24	7.1	6.8	7.1	7.0	0.2
BCST3	JULY 24	7.6	7.4	7.2	7.4	0.2
BCST3	JULY 25	7.3	7.7	7.3	7.4	0.2
REVENUE CREEK	JULY 24	7.4	7.3	7.6	7.4	0.2
REVENUE CREEK	JULY 25	7.4	7.4	7.3	7.4	0.1
BOLIDEN CREEK	JULY 24	6.9		6.9	6.9	
HAPPY CREEK	JULY 24	7.3		7.4	7.4	0.1
TARA CREEK	JULY 24	7.3		7.2	7.3	0.1
TRIBUTARY B	JULY 24					
BCST4	JULY 24	7.3	7.6	7.3	7.4	0.2
SEYMOUR CREEK	JULY 24	7.8	7.7	7.8	7.8	0.1
SEYMOUR CREEK	JULY 25	7.8	7.8	7.8	7.8	
BCST5	JULY 24	7.3	7.4	7.5	7.4	0.1
BCST5	JULY 25	7.3	7.5	7.5	7.4	0.1
STODDART CREEK	JULY 24	7.3	7.3	7.3	7.3	
BCST6	JULY 24	7.5	7.5	7.5	7.5	

APPENDIX IV TABLE 1 [illegible] (CONTINUED)

STATION	DATE	TURBIDITY LEFT F.T.U.	TURBIDITY CENTER F.T.U.	TURBIDITY RIGHT F.T.U.	TURBIDITY AVERAGE F.T.U.	TURBIDITY ST. DEV. F.T.U.
BCST1	JULY 24	<0.1	<0.1	<0.1	<0.1	
TRIBUTARY A	JULY 24	2.9	<0.1	<0.1	1.0	1.6
BERBESS CREEK	JULY 24	<0.1		<0.1	<0.1	
MAGMAN CREEK	JULY 24	<0.1	<0.1	<0.1	<0.1	
BCST2	JULY 24	<0.1	<0.1	<0.1	<0.1	
NONAME CREEK	JULY 24	0.3		0.3	0.3	
MECHANIC CREEK	JULY 24	700.0	8000.0	700.0	3133.3	4214.7
BCST3	JULY 24	2.0	2.0	1.6	1.9	0.2
BCST3	JULY 25	<0.1	<0.1	<0.1	<0.1	
REVENUE CREEK	JULY 24	0.7	2.7	11.0	4.8	5.5
REVENUE CREEK	JULY 25	0.2	15.0	32.0	15.7	15.9
BOLIDEN CREEK	JULY 24	210.0		170.0	190.0	28.3
HAPPY CREEK	JULY 24	1.1		2.5	1.8	1.0
TARA CREEK	JULY 24	2.0		1.6	1.8	0.3
TRIBUTARY B	JULY 24					
BCST4	JULY 24	7.0	7.0	7.0	7.0	
SEYMOUR CREEK	JULY 24	1.6	1.0	0.7	1.1	0.5
SEYMOUR CREEK	JULY 25	0.4	2.0	0.5	1.0	0.9
BCST5	JULY 24	4.2	4.2	4.2	4.2	
BCST5	JULY 25	1.6	1.1	1.0	1.2	0.3
STODDART CREEK	JULY 24	1.3	1.1	1.0	1.1	0.2
BCST6	JULY 24	13.5	13.5	13.5	13.5	

APPENDIX IV TABLE 4 [illegible] WATER QUALITY [illegible] JULY [illegible] (CONTINUED)

STATION	DATE	CONDUCTIVITY LEFT umhos/cm	CONDUCTIVITY CENTER umhos/cm	CONDUCTIVITY RIGHT umhos/cm	CONDUCTIVITY AVERAGE umhos/cm	CONDUCTIVITY ST. DEV. umhos/cm
BCST1	JULY 24	134	134	134	134.0	
TRIBUTARY A	JULY 24	212	212	212	212.0	
BERBESS CREEK	JULY 24	140		140	140.0	
MAGMAN CREEK	JULY 24	132	132	132	132.0	
BCST2	JULY 24	137	137	135	136.3	1.2
NONAME CREEK	JULY 24	146		146	146.0	
MECHANIC CREEK	JULY 24	164	169	164	165.7	2.9
BCST3	JULY 24	132	133	134	133.0	1.0
BCST3	JULY 25	131	133	133	132.3	1.2
REVENUE CREEK	JULY 24	131	132	132	131.7	0.6
REVENUE CREEK	JULY 25	132	133	134	133.0	1.0
BOLIDEN CREEK	JULY 24	419		417	418.0	1.4
HAPPY CREEK	JULY 24	264		264	264.0	
TARA CREEK	JULY 24	142		144	143.0	1.4
TRIBUTARY B	JULY 24					
BCST4	JULY 24	133	133	133	133.0	
SEYMOUR CREEK	JULY 24	213	213	213	213.0	
SEYMOUR CREEK	JULY 25	213	213	212	212.7	0.6
BCST5	JULY 24	133	140	159	144.0	13.5
BCST5	JULY 25	136	154	160	150.0	12.5
STODDART CREEK	JULY 24	139	139	139	139.0	
BCST6	JULY 24	150	150	150	150.0	

APPENDIX IV TABLE 2 [illegible] WATER QUALITY DATA AUGUST

STATION	DATE	FLOW cms	NFR LEFT mg/l	NFR CENTER mg/l	NFR RIGHT mg/l	NFR AVERAGE mg/l	NFR ST. DEV. mg/l
BCST1	AUG 14	1.927	5	5	5	5.0	
TRIBUTARY A	AUG 14	0.018	5	8	5	6.0	1.7
BERBESS CREEK	AUG 14	0.020	74		27	50.5	33.2
MAGMAN CREEK	AUG 14	0.030	5		13	9.0	5.7
BCST2	AUG 14	2.133	5	5	5	5.0	
NONAME CREEK	AUG 14	0.026	6		6	6.0	
MECHANIC CREEK	AUG 14	0.033	86		88	87.0	1.4
BCST3	AUG 14	1.484	6	5	7	6.0	1.0
BCST3	AUG 15		5	7	7	6.3	1.2
REVENUE CREEK	AUG 14	0.273	44	170	257	157.0	107.1
REVENUE CREEK	AUG 15		9	29	53	30.3	22.0
BOLIDEN CREEK	AUG 14	0.008		145		145.0	
HAPPY CREEK	AUG 14	0.004	21		23	22.0	1.4
TARA CREEK	AUG 14	0.002	60		55	57.5	3.5
TRIBUTARY B	AUG 14						
BCST4	AUG 14	2.513	14	13	13	13.3	0.6
SEYMOUR CREEK	AUG 14	1.153	25	20	24	23.0	2.6
SEYMOUR CREEK	AUG 15						
BCST5	AUG 14	3.746	17	21	27	21.7	5.0
BCST5	AUG 15		6	11	13	10.0	3.6
STODDART CREEK	AUG 14	0.639	40	44	38	40.7	3.1
BCST6	AUG 14	4.274	20	21	19	20.0	1.0

APPENDIX IV TABLE 2 [illegible] AUGUST (CONTINUED)

STATION	DATE	pH LEFT UNITS	pH CENTER UNITS	pH RIGHT UNITS	pH AVERAGE UNITS	pH ST. DEV. UNITS
BCST1	AUG 14	7.6	7.5	7.7	7.6	0.1
TRIBUTARY A	AUG 14	8.0	7.9	7.9	7.9	0.1
BERBESS CREEK	AUG 14	7.1		7.1	7.1	
MAGMAN CREEK	AUG 14	7.8		7.7	7.8	0.1
BCST2	AUG 14	7.5	7.5	7.5	7.5	
NONAME CREEK	AUG 14	7.3		7.3	7.3	
MECHANIC CREEK	AUG 14	7.2		7.2	7.2	
BCST3	AUG 14	7.5	7.1	7.4	7.3	0.2
BCST3	AUG 15	7.5	7.3	7.5	7.4	0.1
REVENUE CREEK	AUG 14	7.4	7.2	7.2	7.3	0.1
REVENUE CREEK	AUG 15	7.5	7.4	7.4	7.4	0.1
BOLIDEN CREEK	AUG 14		6.9		6.9	
HAPPY CREEK	AUG 14	7.4		7.4	7.4	
TARA CREEK	AUG 14	7.6		7.6	7.6	
TRIBUTARY B	AUG 14					
BCST4	AUG 14	7.5	7.5	7.7	7.6	0.1
SEYMOUR CREEK	AUG 14	7.9	8.0	7.8	7.9	0.1
SEYMOUR CREEK	AUG 15					
BCST5	AUG 14	7.4	7.6	7.6	7.5	0.1
BCST5	AUG 15	7.6	7.6	7.7	7.6	0.1
STODDART CREEK	AUG 14	7.3	7.3	7.4	7.3	0.1
BCST6	AUG 14	7.3	7.7	7.5	7.5	0.2

APPENDIX IV TABLE 2 [illegible]

STATION	DATE	TURBIDITY LEFT F.T.U.	TURBIDITY CENTER F.T.U.	TURBIDITY RIGHT F.T.U.	TURBIDITY AVERAGE F.T.U.	TURBIDITY ST. DEV. F.T.U.
BCST1	AUG 14	<0.1	<0.1	<0.1	<0.1	
TRIBUTARY A	AUG 14	<0.1	<0.1	<0.1	<0.1	
BERBESS CREEK	AUG 14	3.3		1.1	2.2	1.6
MAGMAN CREEK	AUG 14	<0.1		<0.1	<0.1	
BCST2	AUG 14	<0.1	<0.1	<0.1	<0.1	
NONAME CREEK	AUG 14	<0.1		<0.1	<0.1	
MECHANIC CREEK	AUG 14	105.0		106.0	105.5	0.7
BCST3	AUG 14	0.5	0.2	0.3	0.3	0.2
BCST3	AUG 15	0.5	0.3	0.3	0.4	0.1
REVENUE CREEK	AUG 14	28.0	270.0	450.0	249.3	211.8
REVENUE CREEK	AUG 15	2.7	25.0	40.0	22.6	18.8
BOLIDEN CREEK	AUG 14		5.0		5.0	
HAPPY CREEK	AUG 14	2.7		2.7	2.7	
TARA CREEK	AUG 14	6.5		6.5	6.5	
TRIBUTARY B	AUG 14					
BCST4	AUG 14	0.7	1.3	0.8	0.9	0.3
SEYMOUR CREEK	AUG 14	3.5	5.0	3.8	4.1	0.8
SEYMOUR CREEK	AUG 15					
BCST5	AUG 14	3.6	7.0	11.5	7.4	4.0
BCST5	AUG 15	1.6	1.6	2.0	1.7	0.2
STODDART CREEK	AUG 14	2.9	4.6	3.5	3.7	0.9
BCST6	AUG 14	3.6	7.0	3.6	4.7	2.0

APPENDIX IV TABLE 2 [illegible] AUGUST (CONTINUED)

STATION	DATE	CONDUCTIVITY LEFT umhos/cm	CONDUCTIVITY CENTER umhos/cm	CONDUCTIVITY RIGHT umhos/cm	CONDUCTIVITY AVERAGE umhos/cm	CONDUCTIVITY ST. DEV. umhos/cm
BCBT1	AUG 14	153	152	152	152.3	0.6
TRIBUTARY A	AUG 14	219	219	220	219.3	0.6
BERBERR CREEK	AUG 14	166		167	166.5	0.7
MAGMAN CREEK	AUG 14	139		139	139.0	
BCBT2	AUG 14	154	154	151	153.0	1.7
NONAME CREEK	AUG 14	148		149	148.5	0.7
MECHANIC CREEK	AUG 14	205		196	200.5	6.4
BCBT3	AUG 14	150	152	153	151.7	1.5
BCBT3	AUG 15	151	152	151	151.3	0.6
REVENUE CREEK	AUG 14	145	148	148	147.0	1.7
REVENUE CREEK	AUG 15	146	149	149	148.0	1.7
BOLIDEN CREEK	AUG 14		279		279.0	
HAPPY CREEK	AUG 14	179		179	179.0	
TARA CREEK	AUG 14	164		162	163.0	
TRIBUTARY B	AUG 14					1.4
BCBT4	AUG 14	151	150	158	153.0	4.4
SEYMOUR CREEK	AUG 14	220	220	219	219.7	0.6
SEYMOUR CREEK	AUG 15					
BCBT5	AUG 14	158	170	181	169.7	11.5
BCBT5	AUG 15	161	177	186	174.7	12.7
UTODDART CREEK	AUG 14	133	137	133	134.3	2.3
BCBT6	AUG 14	170	170	163	167.7	4.0

APPENDIX IV TABLE 4 [illegible] SEPTEMBER

STATION	DATE	FLOW cms	NFR LEFT mg/l	NFR CENTER mg/l	NFR RIGHT mg/l	NFR AVERAGE mg/l	NFR ST. DEV. mg/l
BCBT1	SEPT 18	4.068	<5	<5	<5	<5	
TRIBUTARY A	SEPT 18	0.251	<5		<5	<5	
HERMES CREEK	SEPT 18	0.029	<5		<5	<5	
MAGMAN CREEK	SEPT 18	0.085	<5	<5	<5	<5	
BCBT2	SEPT 18	4.467	<5	<5	<5	<5	
NONAME CREEK	SEPT 18	0.063	38		41	39.5	2.1
MECHANIC CREEK	SEPT 18	0.070	40		36	38.0	2.8
BCBT3	SEPT 18	4.512	<5	<5	<5	<5	
BCBT3	SEPT 19		<5	<5	17	9.0	6.9
REVENUE CREEK	SEPT 18	0.008	8		8	8.0	
REVENUE CREEK	SEPT 19		181		184	182.5	2.1
BOLIDEN CREEK	SEPT 18	0.005	4250		4330	4290.0	56.6
HAPPY CREEK	SEPT 18	0.016	6		<5	5.5	0.7
TARA CREEK	SEPT 18	0.004	10		13	11.5	2.1
TRIBUTARY B	SEPT 18	0.092	21		22	21.5	0.7
BCBT4	SEPT 18	4.982	<5	<5	6	5.3	0.6
SEYMOUR CREEK	SEPT 18	1.837	9	7	8	8.0	1.0
SEYMOUR CREEK	SEPT 19		7	5	11	7.7	3.1
BCBT5	SEPT 18	6.842	6	6	<5	5.7	0.6
BCBT5	SEPT 19		5	<5	5	5.0	
STODDART CREEK	SEPT 18	0.634	11	13	11	11.7	1.2
BCBT6	SEPT 18	6.828	5	5	<5	5.0	

APPENDIX IV TABLE 3 SYSTEM REPLICATE WATER QUALITY DATA - SEPTEMBER (CONTINUED)

STATION	DATE	pH LEFT UNITS	pH CENTER UNITS	pH RIGHT UNITS	pH AVERAGE UNITS	pH ST. DEV. UNITS
BCBT1	SEPT 18	7.3	7.4	7.4	7.4	0.1
TRIBUTARY A	SEPT 18	7.7		7.6	7.7	0.1
BERDESS CREEK	SEPT 18	6.9		6.9	6.9	
MAGMAN CREEK	SEPT 18	7.5	7.6	7.6	7.6	0.1
BCBT2	SEPT 18	7.7	7.1	6.9	7.2	0.4
NONAME CREEK	SEPT 18	7.1		7.1	7.1	
MECHANIC CREEK	SEPT 18	7.1		7.1	7.1	
BCBT3	SEPT 18	7.4	7.4	7.4	7.4	
BCBT3	SEPT 19	7.4	7.4	7.2	7.3	0.1
REVENUE CREEK	SEPT 18	7.0		7.0	7.0	
REVENUE CREEK	SEPT 19	6.9		6.9	6.9	
BOLIDEN CREEK	SEPT 18	7.0		7.0	7.0	
HAPPY CREEK	SEPT 18	7.1		7.1	7.1	
TARA CREEK	SEPT 18	7.3		7.3	7.3	
TRIBUTARY B	SEPT 18	7.6		7.6	7.6	
BCBT4	SEPT 18	7.4	7.4	7.4	7.4	
SEYMOUR CREEK	SEPT 18	7.9	7.9	7.8	7.9	0.1
SEYMOUR CREEK	SEPT 19	7.8	7.8	7.8	7.8	
BCBT5	SEPT 18	7.4	7.5	8.0	7.6	0.3
BCBT5	SEPT 19	7.4	7.5	7.5	7.5	0.1
STODDART CREEK	SEPT 18	7.3	7.3	7.3	7.3	
BCBT6	SEPT 18	7.6	7.6	7.6	7.6	

APPENDIX IV TABLE 3 SYSTEM REPLICATE WATER QUALITY DATA -SEPTEMBER (CONTINUED)

STATION	DATE	TURBIDITY LEFT F.T.U.	TURBIDITY CENTER F.T.U.	TURBIDITY RIGHT F.T.U.	TURBIDITY AVERAGE F.T.U.	TURBIDITY ST. DEV. F.T.U.
BCBT1	SEPT 18	0.3	<0.1	<0.1	0.2	0.1
TRIBUTARY A	SEPT 18	<0.1		<0.1	<0.1	
BERBESS CREEK	SEPT 18	2.2		2.2	2.2	
MAGMAN CREEK	SEPT 18	<0.1	<0.1	<0.1	<0.1	
BCBT2	SEPT 18	<0.1	<0.1	<0.1	<0.1	
MONAME CREEK	SEPT 18	2.3		2.3	2.3	
MECHANIC CREEK	SEPT 18	10.0		7.5	8.8	1.8
BCBT3	SEPT 18	0.2	0.1	0.1	0.1	0.1
BCBT3	SEPT 19	0.1	0.1	0.8	0.3	0.4
REVENUE CREEK	SEPT 18	3.1		3.1	3.1	
REVENUE CREEK	SEPT 19	34.0		35.0	34.5	0.7
BOLIDEN CREEK	SEPT 18	2250.0		2250.0	2250.0	
HAPPY CREEK	SEPT 18	2.7		2.7	2.7	
TARA CREEK	SEPT 18	3.8		2.3	3.1	1.1
TRIBUTARY B	SEPT 18	2.7		3.1	2.9	0.3
BCBT4	SEPT 18	<0.1	<0.1	0.1	0.1	
SEYMOUR CREEK	SEPT 18	2.3	2.1	1.7	2.0	0.3
SEYMOUR CREEK	SEPT 19	1.0	0.3	1.5	0.9	0.6
BCBT5	SEPT 18	0.1	0.3	0.2	0.2	0.1
BCBT5	SEPT 19	<0.1	<0.1	0.3	0.2	0.1
STODDART CREEK	SEPT 18	0.1	0.1	0.1	0.1	
BCBT6	SEPT 18	0.2	0.1	0.1	0.1	0.1

APPENDIX IV TABLE 3 SYSTEM REPLICATE WATER QUALITY DATA -SEPTEMBER (CONTINUED)

STATION	DATE	CONDUCTIVITY LEFT umhos/cm	CONDUCTIVITY CENTER umhos/cm	CONDUCTIVITY RIGHT umhos/cm	CONDUCTIVITY AVERAGE umhos/cm	CONDUCTIVITY ST. DEV. umhos/cm
BCST1	SEPT 18	138	136	137	137.0	1.0
TRIBUTARY A	SEPT 18	171		175	173.0	2.8
BERBESS CREEK	SEPT 18	85		87	86.0	0.8
HAGMAN CREEK	SEPT 18	129	132	129	130.0	1.7
BCST2	SEPT 18	142	143	142	142.3	0.6
NONAME CREEK	SEPT 18	91		94	92.3	1.7
MECHANIC CREEK	SEPT 18	82		139	110.5	40.4
BCST3	SEPT 18	141	141	141	141.0	
BCST3	SEPT 19	144	143	140	142.3	2.1
REVENUE CREEK	SEPT 18	192		195	193.5	2.1
REVENUE CREEK	SEPT 19	190		189	189.5	0.7
BOLIDEN CREEK	SEPT 18	297		290	293.5	4.9
HAPPY CREEK	SEPT 18	142		142	142.0	
TARA CREEK	SEPT 18	120		121	120.5	0.7
TRIBUTARY B	SEPT 18	180		180	180.0	
BCST4	SEPT 18	140	140	140	140.0	
SEYMOUR CREEK	SEPT 18	210	215	214	213.0	2.6
SEYMOUR CREEK	SEPT 19	214	214	214	214.0	
BCST5	SEPT 18	143	151	187	160.3	23.4
BCST5	SEPT 19	142	161	174	159.0	16.1
STODDART CREEK	SEPT 18	121	121	121	121.0	
BCST6	SEPT 18	156	156	152	154.7	2.3

APPENDIX V

FISH INVENTORY DATA

Appendix

The following data have been taken from the notes of Bruce Clark, the Habitat Biologist who conducted this inventory.

August 24, 1984

Beach Seine, Big Creek near confluence with Revenue Creek. Water temp 11°C.

6 sets

Chinook	Grayling	W.F.
8.0 cm	14.5 cm	22.0 cm
6.5	13.0	23.0
6.5	15.0	19.0
8.5	16.0	21.0
7.0	17.0	18.0
8.0	16.5	27.0
8.0	12.0	27.5
6.0	10.0	20.0
8.0	18.0	31.0
7.0	17.5	23.0
6.5	10.0	27.0
7.0	9.0	30.0
6.8	20.0	30.5
7.5	22.0	25.0
8.5	20.0	22.0
8.0	18.0	17.0
7.5	14.0	45.0
8.0	20.0	
7.0	13.0	
	14.0	
	13.0	
	13.5	
	17.0	
	8.0	
	13.0	
	15.0	
	15.0	
	12.0	
	13.5	
	8.0	
	11.0	

...../2

August 25, 1984

Magman Creek 9°C
Big Creek 9°C

Magman Creek @ 600 m above confluence.

Grayling

30.5 cm
29.0
28.0
21.8
27.0
22.5
26.5
17.8
27.4

App. 10 more adult grayling ob served, 1 or two in each deep run or pool. None in riffles or debris. Visibility good but no juvenile grayling, chinook or whitefish.

August 26, 1984.

Big Creek 6°C

Wet snow and rain since previous evening.

Revenue Creek. Water temp 6°C
- much affected by mining
- entire creek shocked, resulted in capture of 5 WF and number of sculpins
- creek largely made up of water from Big Creek via diversion channel

Boliden Creek

- trickle in deep dirt/debris channel. No habitat.

August 27, 1984

Heavy overcast, light-medium snow.
Helicopter does not show.

Mechanic Creek water temp. 3°C.
Big Creek downstream of Mechanic Creek - water temp. 5°C

Grayling
17.3 cm
16.8
19.5
18.9
15.2
18.7

...../3

- several more sets over app 500 m of Big Creek downstream of Mechanic Creek produced more similar sized grayling and whitefish, but no juvenile grayling, whitefish or chinook.

August 28, 1984

Big Creek @ Revenue Strip. Water temp 6°C

Chinook	Grayling	Whitefish
7.1 cm	15.9 cm	15.8 cm
8.0	12.7	
7.0	19.0	
7.5	12.4	
7.3	13.8	
7.4	13.4	
	20.3	
	20.6	
	9.1	
	17.4	
	20.4	
	24.9	
	9.7	

Big Creek @ Revenue Creek

Chinook	Grayling	Whitefish
ø	11.8 cm	ø
	14.3	
	15.6	
	4.7	
	5.9	
	5.7	
	20.6	
	18.0	
	19.3	
	18.0	
	16.8	
	18.7	
	5.3	
	5.4	

Big Creek @ Magman Creek

Chinook	Grayling	Whitefish
ø	30.9 cm	ø
	26.1	
	25.6	

...../4

August 29, 1984

Seymour Creek water temp 2°C
Station 1

Chinook	Grayling	Whitefish
Ø	26.3 cm 30.4	Ø

Station 2 - no fish

Station 3

Chinook	Grayling	Whitefish
Ø	37.5 cm	Ø

Station 4 - at confluence with Big Creek

Chinook	Grayling	Whitefish
Ø	30.0 cm	Ø

Float of Big Creek Magman to Mechanic observed 63 grayling, 35 of which were in large school.

August 30, 1984

Station 1 (at second road crossing) water temp 3°C

Chinook	Grayling	Whitefish
7.4	26.3 cm 19.8	Ø

Station 2

Chinook	Grayling	Whitefish
Ø	25.9 cm 23.9	Ø

Debris jams

- Upper trib to Bow Creek.
  Major flood plain surface disturbance from mining.

...../5

Big Creek Station 3 water temp 4°C

Chinook	Grayling	Whitefish
Ø	35.4 cm	Ø
	17.1	
	19.1	
	27.0	
	25.8	
	22.7	
	27.3	
	25.2	
	19.5	
	13.5	
	13.8	

Observed 31 additional grayling

August 31, 1984

Seymour Creek water temp 5°C

Station 5

Chinook	Grayling	Whitefish
6.7 cm	Ø	Ø

Station 6

Seymour/Bow confluence (deep pool)

Chinook	Grayling
7.7 cm	26.3 cm
7.9	27.9
7.4	29.7
	27.0
	26.0
	25.5
	25.9
	28.8
	23.1

Seymour 100 m upstream of confluence.
- no fish.
- shocker not working well.

...../6

September 8, 1984

Water temp 3°C.
Water high and tea coloured.
No landing sites at mouth.

Station 1 - Grayling, 33.0 cm

Station 2 - Chinook, 6.8 cm
7.2 cm

Station 3 - Chinook, 7.4 cm

APPENDIX VI

BENTHIC INVERTEBRATE AND SEDIMENT CHARACTERISTICS

APPENDIX VI TABLE 1 BOTTOM FAUNA TAXONOMIC GROUPS

1.	Phylum:	Arthropoda
2.	Class:	Arachonoidae
3.	Order:	Acari
4.	Class:	Ostracoda
5.	Class:	Insecta
6.	Order:	Collembola
7.	Family:	Entomobryidae
8.	Family:	Isotomidae
9.		*Isotoma* sp.
10.	Order:	Homoptera
11.	Family:	Aphididae
12.	Family:	Cicadellidae
13.	Order:	Coleoptera
14.	Family:	Tenebrionidae
15.	Family:	Cantharidae
16.	Family:	Chrysomelidae
17.	Family:	Hydrophilidae
18.		*Helophorus* sp.
19.	Order:	Hymenoptera
20.		Symphyta
21.	Order:	Lepidoptera
22.	Order:	Ephemeroptera
23.	Family:	Baetidae
24.		*Baetis laponicus*
25.		*Baetis insignificans*
26.		*Pseudocloeon* sp.
27.	Family:	Heptageniidae
28.		*Cinygmula* sp.?
29.		*Epeorus* sp.
30.	Family:	Leptophlebiidae
31.		*Choroterpes* sp.?
32.		*Paraleptophelia* sp.

APPENDIX VI TABLE 1 BOTTOM FAUNA TAXONOMIC GROUPS
(Continued)

33.	Family:	Ephemerellidae
34.		*Ephemerella coloradensis*
35.		*Ephemerella seratella*
36.		*Ephemerella (Drunella)* sp.
37.		*Ephemerella attenuatella*
38.		*Ephemerella doddsi*
39.		*Ephemerella mollita*
40.		*Ephemerella intermis*
41.	Family:	Siphlonuridae
42.		*Ameletus* sp.
43.	Order:	Plecoptera
44.	Family:	Perlodidae
45.		*Skwala* sp.
46.		*Cultus* sp.
47.		*Arcynopteryx* sp.
48.		*Isoperla* sp.
49.	Family:	Chloroperlidae
50.		*Kathroperla perdita*
51.		*Alloperla* sp.
52.		*Utaperla sopladora*
53.	Family:	Capnildae
54.		*Capnia* sp.
55.	Family:	Taeniopterygidae
56.		*Brachyptera* sp.
57.	Family:	Nemouridae
58.		*Zapada* sp.
59.		*Podmosta* sp.
60.	Order:	Trichoptera
61.	Family:	Brachycentridae
62.		*Brachycentrus* sp.
63.	Family:	Apataniidae
64.		*Apatania* sp.
65.		*Anagapetus* sp.

APPENDIX VI TABLE 1 BOTTOM FAUNA TAXONOMIC GROUPS
(Continued)

66.	Family:	Rhyacophilidae
67.		*Agapetus* sp.
68.	Family:	Limnephilidae
69.		*Ecclisomyia* sp.
70.	Order:	Diptera
71.	Family:	Simuliidae
72.		*Simulium* sp.
73.		*Prosimulium* sp.
74.	Family:	Chironomidae
75.		Chironomidae pupae
76.	Subfamily:	Orthocladiinae
77.		*Cricotopus* sp.
78.		*Heterotrissocladius* sp.
79.		*Cardiocladius* sp.
80.		*Eukiefferiella* sp.
81.		*Orthocladius* sp.
82.		*Corynoneura* sp.
83.		*Smittia* sp.
84.		*Epoicocladius* sp.
85	Subfamily:	Diamesinae
86.		*Diamesa* sp.
87.		*Monodiamesa* sp.
88.		*Pseudodiamesa* sp.
89.	Subfamily:	Tanypodinae
90.		*Microspectra* sp.
91.		*Trichocladius* sp.
92.	Family:	Tipulidae
93.		*Tipula* sp.
94.	Family:	Empididae
95.		*Chelifera* sp.
96.	Family:	Ceratopogonidae
97.		*Palpomyia* sp.
98.		*Culicoides* sp.

APPENDIX VI TABLE 1 BOTTOM FAUNA TAXONOMIC GROUPS
(Continued)

99.	Family:	Tabanidae
100.	Family:	Muscidae
101.	Family:	Sciomyzidae
102.	Family:	Nematoda
103.	Phylum:	Annelida
104.	Class:	Oligochaeta
105.	Order:	Haplotaxida
106.	Family:	Haplotaxidae
107.		Haplotaxis gordioides
108.	Family:	Enchytraeidae
109.	Family:	Tubificidae
110.		Tubifex sp.
111.	Family:	Naididae
112.		Nais sp.
113.		Pristina sp.
114.	Order:	Lumbriculida
115.	Family:	Lumbriculidae
116.		Kincaidiana hexatheca

APPENDIX VI TABLE 2 BENTHIC INVERTEBRATE ABUNDANCE - JULY 24, 1984

	STATION						Stodd.
	1	2	3	4	5	6	Creek
3. Acari					1		
7. Entomobryidae	6	1					
11. Aphididae		1	5	2			
12. Cicadellidae						1	
14. Tenebrionidae				1			
15. Cantharidae					1		
21. Lepidoptera				1			1
24. Baetis laponicus	67	46	15	34	13	23	17
26. Pseudocloeon sp.	17	51	33	99	58	28	21
28. Cinygmula sp.	53	52	34	15	27	15	3
29. Epeorus sp.	6	5	4	7	11	6	
32. Paraleptophelia sp.	45	14	16	5	18	6	1
34. Ephemerella coloradensis	1						
37. Ephemerella attenuatella	2	1	4	14	3		
38. Ephemerella doddsi		1	2	5		1	
40. Ephemerella infrmis		1	1	2	1	1	
42. Ameletus sp.			1				
46. Cultus sp.	4	3	1	2	4	1	2
48. Isoperla sp.		1					
51. Alloperla sp.	6	31	11	2		4	3
52. Utaperla sopiadora	2	2			9	1	
55. Capnia sp.							2
59. Podmosta sp.						1	4
62. Brachycentrus sp.					1	1	
67. Agapetus sp.			1				
68. Limnephilidae					1		
72. Simulium sp.				2			
73. Prosimulium sp.	12	4	12	2	1		2
75. Chironomidae pupae	106	43	53	22	19	26	8
77. Cricotopus sp.	72		14	46	3	68	63
78. Heterotrissocladius sp.	39		7	27	5	11	18
79. Cardiocladius sp.	3		1	3	3	2	
80. Eukiefferiella sp.	1			1		2	
81. Orthocladius sp.				2		1	
82. Corynoneura sp.	1		4			2	
84. Epoicocladius sp.	60		3	13	2	21	12
88. Pseudodiamesa sp.	3		2	1		1	23
90. Microspectra sp.	8	1					
95. Chelifera sp.	57	81	13	15	10	6	4
96. Ceratopogonidae					1		

APPENDIX VI TABLE 2 BENTHIC INVERTEBRATE ABUNDANCE - JULY 24, 1984 (Continued)

	STATION						Stodd. Creek
	1	2	3	4	5	6	
98. *Culicoides* sp.		1					1
100. Muscidae	1						
101. Sciomyzidae						1	
102. Nematoda				1	4	3	1
107. *Haplotaxis gordioides*	1	1	1				
108. Enchytraeidae		29	2		8		6
109. Tubificidae	1	4	1	2			1
110. *Tubifex* sp.				1			
111. Naididae					5	1	
TOTAL NUMBER	574	374	241	327	209	234	193
DENSITY NUMBER/FT^2	115	74.8	48.2	65.4	41.8	46.8	38.6

APPENDIX VI TABLE 2 BENTHIC INVERTEBRATE ABUNDANCE - AUGUST 14, 1984

	STATION						Stodd.
	1	2	3	4	5	6	Creek
3. Acari	4			1	1	1	
4. Ostracoda						1	
9. Isotoma sp.	1	3		1			
11. Aphididae		1	3	1	1		
16. Chrysomelidae		1					
20. Symphyta							1
24. Baetis laponicus	2	1	2	1	18	2	35
25. Baetis insignificans	34	20	28	50	59	2	24
28. Cinygmula sp.	66	65	207	47	34	5	19
29. Epeorus sp.		1	6	1			2
31. Choroterpes sp.?				20	8	2	2
35. Ephemerella seratella	8	17	44	5	15		
38. Ephemerella doddsi			4	4	2		1
39. Ephemerella mollita	3		1	9	26	2	22
42. Ameletus sp.	1				3	1	
47. Arcynopteryx sp.	6	2	21	20	18	12	6
48. Isoperla sp.		1					
50. Kathroperla perdita	4	7	2				
51. Alloperla sp.		4	15		2		
54. Capnia sp.	2				1		
58. Zapada sp.	1						
59. Podmosta sp.	1				7		3
64. Apatania sp.	5	14		4	1		
69. Ecclisomyia sp.		6		2	1		
73. Prosimulium sp.			1			2	
74. Chironomidae		1		4	4	5	3
75. Chironomidae pupae	12	7	14	3	12	4	2
76. Orthocladiinae			1				
77. Cricotopus sp.	78	77	282	29	109	110	46
78. Heterotrissocladius sp.	21	7	85	5	17	7	5
79. Cardiocladius sp.	8	7	19	1	8	7	1
80. Eukiefferiella sp.	4	9	4	1	8	10	3
81. Orthocladius sp.	4	2				1	2
82. Corynoneura sp.	1					2	1
83. Smittia sp.			1			1	
85 Diamesinae				1	1		
86. Diamesa sp.	4	2			1		1
90. Microspectra sp.	2						
91. Trichocladius sp.	25	20	2	1	1	1	1
93. Tipula sp.		2				1	1
95. Chelifera sp.	3	3				4	1

APPENDIX VI TABLE 2 BENTHIC INVERTEBRATE ABUNDANCE - AUGUST 14, 1984 (Continued)

	STATION						Stodd.
	1	2	3	4	5	6	Creek
97. *Palpomyia* sp.	10		1				
102. Nematoda		2	3		1	5	3
107. *Haplotaxis gordioides*							1
108. Enchytraeidae	11	7	2	3	8		11
109. Tubificidae	17	11			2		8
110. *Tubifex* sp.							2
113. *Pristina* sp.		11		3		1	
TOTAL NUMBER	338	311	748	217	369	189	207
DENSITY NUMBER/FT^2	67.6	62.2	150	43.4	73.8	37.8	41.4

APPENDIX VI TABLE 2 BENTHIC INVERTEBRATE ABUNDANCE - SEPTEMBER 18, 1984

	STATION						Stodd
	1	2	3	4	5	6	Creek
3. Acari	1	1	2			2	
9. Isotoma sp.			1				
11. Aphididae			8	2	2	4	3
18. Helophorus sp.				1			
24. Baetis laponicus	3	1	3		2	5	56
25. Baetis insignificans				1	1		1
28. Cinygmula sp.?	642	145	205	161	116	83	15
29. Epeorus sp.					4	3	
31. Choroterpes sp.?	4		1	32	18	6	
36. Ephemerella (Drunella) sp.		1					
38. Ephemerella doddsi			2	2	6	3	1
39. Ephemerella mollita	10	9	23	8	11	6	
42. Ameletus sp.		2					
45. Skwala sp.		3	6	7			
47. Arcynopteryx sp.	1			1	6	9	1
48. Isoperla sp.	3	2	2		6		
50. Kathroperla perdita	15	24	2				
51. Alloperla sp.	15	10	1	1	14	1	
54. Capnia sp.			13	3	8	11	9
56. Brachyptera sp.				1	4	5	
58. Zapada sp.					1		
59. Podmosta sp.	1				1		29
64. Apatania sp.	5	8	3	2		1	
65. Anagapetus sp.		1		2		1	1
69. Ecclisomyia sp.	2	2	2	2	1		
74. Chironomidae			1	1	2	1	
75. Chironomidae pupae	1	1	3	4		4	1
77. Cricotopus sp.	10	27	7	23	29	64	4
78. Heterotrissocladius sp.	8	1	1	2	1	10	2
79. Cardiocladius sp.	1	2	4	3		2	1
80. Eukiefferiella sp.		1	3	1		4	1
81. Orthocladius sp.				1		1	
83. Smittia sp.		2					
85 Diamesinae		1	2			1	
86. Diamesa sp.			2	1	4	2	2
87. Monodiamesa sp.							4
90. Microspectra sp.		4					
93. Tipula sp.	1		1		1		
94. Empididae						1	
95. Chelifera sp.	2	2			1		
97. Palpomyia sp.	1						

APPENDIX VI TABLE 2 BENTHIC INVERTEBRATE ABUNDANCE - SEPTEMBER 18, 1984 (Continued)

	STATION						
	1	2	3	4	5	6	Stodd Creek
102. Nematoda	3		3		2	2	
107. Haplotaxis gordioides	2	1			1		
108. Enchytraeidae	1	74	2	3	10		10
109. Tubificidae	18	6	2	4	13	1	6
110. Tubifex sp.				3	5		
112. Nais sp.					2		
113. Pristina sp.	7	15					1
116. Kincaidiana hexatheca					1		
TOTAL NUMBER	757	346	305	272	273	233	148
DENSITY NUMBER/FT^2	151	69.2	61.0	54.4	54.6	46.6	29.6

APPENDIX VI TABLE 3 BIG CREEK SEDIMENT ANALYSIS-PARTICLE SIZES
PERCENTAGE OF DRY WEIGHT

STATION 1

PARTICLE SIZE (mm)	1-1	1-2	1-3	$\bar{x}$	S.D.	V*
JULY 24, 1984						
>2.0	45.8	48.7	54.8	49.8	4.6	10.0
>1.0 -<2.0	24.2	15.5	18.2	19.3	4.5	25.0
>0.50 -<1.0	21.5	26.9	21.2	23.2	3.2	15.0
>0.25 -<0.50	6.4	7.5	4.7	6.2	1.4	24.6
>0.15 -<0.25	1.6	1.1	0.7	1.1	0.5	43.1
>0.063-<0.15	0.3	0.2	0.2	0.2	0.1	26.8
<0.063	0.2	0.1	0.1	0.1	0.1	46.9
AUGUST 14, 1984						
>2.0	21.0	0.2	40.0	20.4	19.9	106
>1.0 -<2.0	44.6	0.3	31.8	25.6	22.8	96.6
>0.50 -<1.0	30.7	3.2	20.7	18.2	13.9	82.9
>0.25 -<0.50	2.9	19.2	5.5	9.2	8.8	103
>0.15 -<0.25	0.4	26.8	1.5	9.6	14.9	169
>0.063-<0.15	0.2	26.0	0.3	8.8	14.9	182
<0.063	0.1	24.3	0.2	8.2	13.9	184
SEPTEMBER 18, 1984						
>2.0	52.6	40.6	47.1	46.8	6.0	13.9
>1.0 -<2.0	19.3	19.7	21.7	20.2	1.3	6.9
>0.50 -<1.0	19.4	24.8	22.1	22.1	2.7	13.2
>0.25 -<0.50	5.6	9.8	5.6	7.0	2.4	37.5
>0.15 -<0.25	1.5	2.9	1.6	2.0	0.8	42.3
>0.063-<0.15	0.9	1.5	1.2	1.2	0.3	27.1
<0.063	0.6	0.6	0.8	0.7	0.1	18.8

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 3 BIG CREEK SEDIMENT ANALYSIS-PARTICLE SIZES
PERCENTAGE OF DRY WEIGHT

STATION 2

PARTICLE SIZE (mm)	2-1	2-2	2-3	$\bar{x}$	S.D.	V*
JULY 24, 1984						
>2.0	44.0	47.1	24.5	38.5	18.9	53.2
>1.0 -<2.0	19.9	19.4	26.2	21.8	5.7	28.4
>0.50 -<1.0	24.1	21.4	37.3	27.6	13.3	52.2
>0.25 -<0.50	10.0	9.2	10.6	9.9	1.2	13.5
>0.15 -<0.25	1.7	2.2	1.2	1.7	0.9	55.2
>0.063-<0.15	0.2	0.4	0.1	0.2	0.3	126
<0.063	0.2	0.3	0.1	0.2	0.2	93.8
AUGUST 14, 1984						
>2.0	0.3	1.5	3.9	1.9	2.4	135
>1.0 -<2.0	10.5	11.3	32.0	17.9	17.7	107
>0.50 -<1.0	69.8	31.3	54.7	51.9	31.9	66.6
>0.25 -<0.50	18.4	46.9	8.9	24.7	35.4	155
>0.15 -<0.25	0.6	8.7	0.3	3.2	8.5	288
>0.063-<0.15	0.1	0.3	0.1	0.2	0.2	134
<0.063	0.2	0.1	0.1	0.1	0.1	60.6
SEPTEMBER 18, 1984						
>2.0	44.2	33.3	57.8	45.1	21.0	50.4
>1.0 -<2.0	20.0	24.2	17.3	20.5	6.1	32.5
>0.50 -<1.0	22.8	30.0	16.8	23.2	11.6	54.0
>0.25 -<0.50	8.5	10.0	5.9	8.1	3.5	46.2
>0.15 -<0.25	3.0	1.8	1.4	2.1	1.0	53.0
>0.063-<0.15	1.3	0.6	0.6	0.8	0.5	67.8
<0.063	0.3	0.2	0.2	0.2	0.1	34.6

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 3 BIG CREEK SEDIMENT ANALYSIS-PARTICLE SIZES
PERCENTAGE OF DRY WEIGHT

STATION 3

PARTICLE SIZE (mm)	3-1	3-2	3-3	$\bar{x}$	S.D.	V*
JULY 24, 1984						
>2.0	52.9	41.0	65.1	53.0	20.8	42.6
>1.0 -<2.0	12.1	14.0	20.1	15.4	5.6	39.5
>0.50 -<1.0	8.3	19.5	11.9	13.2	9.6	78.7
>0.25 -<0.50	9.7	16.1	2.3	9.4	11.9	137
>0.15 -<0.25	9.4	6.5	0.5	5.5	5.9	116
>0.063-<0.15	6.4	2.2	0.1	2.9	3.9	144
<0.063	1.2	0.6	0.1	0.6	0.7	114
AUGUST 14, 1984						
>2.0	73.8	59.9	63.7	65.8	10.3	17.0
>1.0 -<2.0	14.8	20.3	14.4	16.5	5.9	38.7
>0.50 -<1.0	8.5	14.5	14.5	12.5	4.5	38.8
>0.25 -<0.50	1.9	3.8	5.3	3.7	2.1	61.0
>0.15 -<0.25	0.7	1.2	1.7	1.2	0.6	55.3
>0.063-<0.15	0.1	0.2	0.2	0.2	0.1	48.4
<0.063	0.1	0.1	0.1	0.1	0.0	0.0
SEPTEMBER 18, 1984						
>2.0	69.1	62.9	72.9	68.3	8.9	14.2
>1.0 -<2.0	14.8	16.0	14.1	15.0	1.7	12.3
>0.50 -<1.0	10.1	14.8	9.2	11.4	5.4	51.4
>0.25 -<0.50	3.6	4.1	2.6	3.4	1.3	39.9
>0.15 -<0.25	1.2	1.3	0.6	1.0	0.6	61.5
>0.063-<0.15	0.8	0.7	0.4	0.6	0.3	47.5
<0.063	0.3	0.2	0.1	0.2	0.1	66.3

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 3 BIG CREEK SEDIMENT ANALYSIS-PARTICLE SIZES
PERCENTAGE OF DRY WEIGHT

STATION 4

PARTICLE SIZE (mm)	4-1	4-2	4-3	$\bar{x}$	S.D.	V*
JULY 24, 1984						
>2.0	28.4	57.2	64.1	49.9	23.2	50.4
>1.0 -<2.0	46.8	16.8	16.5	26.7	22.4	90.9
>0.50 -<1.0	17.9	16.6	12.3	15.6	3.9	27.4
>0.25 -<0.50	2.5	6.2	4.3	4.3	2.9	73.5
>0.15 -<0.25	2.4	2.3	2.0	2.2	0.3	13.5
>0.063-<0.15	1.2	0.6	0.5	0.8	0.5	66.4
<0.063	0.8	0.4	0.3	0.5	0.3	70.2
AUGUST 14, 1984						
>2.0	9.8	9.5	2.5	7.3	6.0	89.3
>1.0 -<2.0	18.1	27.6	0.9	15.5	22.6	157
>0.50 -<1.0	48.0	44.5	5.5	32.7	33.7	112
>0.25 -<0.50	17.3	12.0	8.7	12.7	5.2	44.7
>0.15 -<0.25	5.7	3.6	13.2	7.5	8.0	116
>0.063-<0.15	0.9	1.0	29.6	10.5	24.3	251
<0.063	0.2	1.8	39.5	13.8	32.3	253
SEPTEMBER 18, 1984						
>2.0	70.6	50.5	73.0	64.7	22.1	37.0
>1.0 -<2.0	8.3	2.2	8.6	6.4	6.4	110
>0.50 -<1.0	5.8	2.8	4.4	4.3	2.4	60.1
>0.25 -<0.50	7.4	8.3	6.2	7.3	1.8	26.6
>0.15 -<0.25	4.5	10.4	4.4	6.4	6.1	103
>0.063-<0.15	2.7	18.2	2.6	7.8	16.0	221
<0.063	0.7	7.0	0.7	2.8	6.5	250

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 3 BIG CREEK SEDIMENT ANALYSIS-PARTICLE SIZES
PERCENTAGE OF DRY WEIGHT

STATION 5

PARTICLE SIZE (mm)	5-1	5-2	5-3	$\bar{x}$	S.D.	V*
JULY 24, 1984						
>2.0	67.4	62.8	53.5	61.2	9.2	16.2
>1.0 -<2.0	9.7	12.0	10.3	10.7	2.0	20.7
>0.50 -<1.0	14.3	13.9	17.3	15.2	2.9	20.4
>0.25 -<0.50	5.9	7.3	12.0	8.4	4.3	55.5
>0.15 -<0.25	1.9	2.9	3.9	2.9	1.2	45.8
>0.063-<0.15	0.4	0.7	1.7	0.9	0.9	106
<0.063	0.3	0.4	1.4	0.7	0.9	134
AUGUST 14, 1984						
>2.0	57.4	71.9	72.2	67.2	10.9	17.5
>1.0 -<2.0	7.1	9.2	18.3	11.5	8.2	76.6
>0.50 -<1.0	16.0	8.2	6.7	10.3	6.2	64.9
>0.25 -<0.50	13.8	6.2	1.8	7.3	7.3	109
>0.15 -<0.25	4.2	3.2	0.8	2.7	2.3	90.8
>0.063-<0.15	0.9	1.1	0.1	0.7	0.8	130
<0.063	0.5	0.3	0.1	0.3	0.2	88.5
SEPTEMBER 18, 1984						
>2.0	67.6	64.1	73.1	68.3	7.6	12.1
>1.0 -<2.0	9.2	15.5	7.6	10.8	7.5	75.3
>0.50 -<1.0	9.8	11.8	6.7	9.4	4.3	49.7
>0.25 -<0.50	6.6	4.3	4.4	5.1	1.7	36.1
>0.15 -<0.25	2.6	2.1	3.2	2.6	0.9	38.8
>0.063-<0.15	2.9	1.5	3.2	2.5	1.6	69.6
<0.063	1.3	0.6	1.8	1.2	1.1	93.2

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 3 BIG CREEK SEDIMENT ANALYSIS-PARTICLE SIZES
PERCENTAGE OF DRY WEIGHT

STATION 6

PARTICLE SIZE (mm)	6-1	6-2	6-3	$\bar{x}$	S.D.	V*
JULY 24, 1984						
>2.0	31.1	61.8	58.6	50.5	22.6	48.4
>1.0 -<2.0	45.6	18.9	16.6	27.0	20.3	81.5
>0.50 -<1.0	11.9	6.6	10.9	9.8	4.9	54.0
>0.25 -<0.50	4.1	4.8	5.4	4.8	0.8	18.0
>0.15 -<0.25	4.1	4.0	4.4	4.2	0.3	8.7
>0.063-<0.15	1.9	2.8	3.3	2.7	0.9	34.7
<0.063	1.1	1.1	0.8	1.0	0.3	27.6
AUGUST 14, 1984						
>2.0	59.7	21.2	31.2	37.4	28.5	82.5
>1.0 -<2.0	14.1	48.8	46.2	36.4	25.6	76.2
>0.50 -<1.0	9.8	11.1	10.6	10.5	1.0	10.2
>0.25 -<0.50	7.8	6.0	3.3	5.7	2.9	54.2
>0.15 -<0.25	4.9	6.5	3.6	5.0	2.5	55.1
>0.063-<0.15	2.6	4.3	2.6	3.2	1.7	59.7
<0.063	1.0	2.1	2.4	1.8	0.9	53.2
SEPTEMBER 18, 1984						
>2.0	71.6	74.8	65.2	70.5	8.1	12.4
>1.0 -<2.0	8.8	8.9	15.2	11.0	5.4	53.0
>0.50 -<1.0	8.1	7.0	9.7	8.3	2.3	30.1
>0.25 -<0.50	5.9	4.6	4.6	5.0	1.0	20.9
>0.15 -<0.25	3.1	2.5	2.7	2.8	0.4	17.6
>0.063-<0.15	1.9	1.7	1.8	1.8	0.2	9.5
<0.063	0.6	0.6	0.8	0.7	0.2	27.6

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 3 BIG CREEK SEDIMENT ANALYSIS-PARTICLE SIZES
PERCENTAGE OF DRY WEIGHT

STODDART CREEK

PARTICLE SIZE (mm)	Stod. 1	Stod. 2	Stod. 3	$\bar{x}$	S.D.	V*
JULY 24, 1984						
>2.0	60.7	46.7	57.5	55.0	12.6	24.9
>1.0 -<2.0	13.2	29.3	23.4	22.0	12.2	60.0
>0.50 -<1.0	16.3	16.7	14.1	15.7	2.2	15.0
>0.25 -<0.50	7.8	5.5	2.8	5.4	3.1	62.5
>0.15 -<0.25	1.5	1.6	1.1	1.4	0.4	32.4
>0.063-<0.15	0.2	0.1	0.4	0.2	0.3	117
<0.063	0.2	0.1	0.5	0.3	0.3	136
AUGUST 14, 1984						
>2.0	76.5	77.7	89.3	81.2	10.1	13.4
>1.0 -<2.0	9.9	11.9	5.6	9.1	5.3	62.9
>0.50 -<1.0	6.6	7.7	2.2	5.5	4.6	90.6
>0.25 -<0.50	4.3	1.8	2.1	2.7	1.8	72.8
>0.15 -<0.25	1.9	0.5	0.7	1.0	1.0	108
>0.063-<0.15	0.5	0.1	0.1	0.2	0.3	138
<0.063	0.4	0.1	0.1	0.2	0.2	121
SEPTEMBER 18, 1984						
>2.0	72.2	78.9	76.7	75.9	5.0	7.2
>1.0 -<2.0	11.7	8.3	8.1	9.4	2.6	29.7
>0.50 -<1.0	6.2	4.8	5.1	5.4	1.0	20.8
>0.25 -<0.50	5.8	5.1	6.8	5.9	1.4	26.6
>0.15 -<0.25	2.3	1.7	2.2	2.1	0.6	29.4
>0.063-<0.15	1.3	0.7	1.0	1.0	0.5	51.4
<0.063	0.5	0.4	0.3	0.4	0.1	33.2

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 4 BIG CREEK SEDIMENT ANALYSIS - METALS - JULY 24, 1984
(all concentrations given in mg/L unless otherwise noted)

STATION	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg
1-1	<0.080	16100	<8.0	160	<0.20	9030	<0.30	16.8	67.7	19.9	43200	0.068	1500	7940
1-2	<0.080	17000	<8.0	125	<0.20	9630	<0.30	15.3	69.2	21.3	41500	0.067	1500	8790
1-3	0.20	17700	<8.0	127	<0.20	9750	<0.30	15.4	66.5	23.6	35900	0.079	1500	9180
$\bar{x}$	<0.10	16900	<8.0	137	<0.20	9470	<0.30	15.8	67.8	21.6	40200	0.071	1500	8640
S.D.	--	802	--	19.7	--	386	--	0.8	1.4	1.9	3820	0.007	0.0	634
V*	--	5.1	--	15.5	--	4.4	--	5.7	2.2	9.4	10.3	10.1	0.0	8.0
2-1	<0.080	16000	<8.0	148	<0.20	9260	<0.30	18.2	63.1	22.3	54100	0.073	1500	7680
2-2	<0.080	15800	<8.0	135	<0.20	9250	<0.30	17.1	52.0	19.1	44800	0.071	1450	7230
2-3	<0.080	15400	<8.0	146	<0.20	8900	<0.30	14.7	49.3	19.3	35600	0.077	1500	7590
$\bar{x}$	<0.080	15700	<8.0	143	<0.20	9140	<0.30	16.7	54.8	20.2	44800	0.074	1480	7500
S.D.	--	305	--	7.0	--	205	--	1.8	7.3	1.8	9250	0.003	28.9	238
V*	--	2.1	--	5.3	--	2.4	--	11.6	14.5	9.6	22.4	4.5	2.1	3.4
3-1	<0.080	14500	<8.0	161	<0.20	8120	0.40	15.8	44.0	27.6	38100	0.060	1500	6280
3-2	<0.080	12500	<8.0	185	<0.20	8900	<0.30	35.0	111	26.3	158000	0.106	1200	5860
3-3	<0.080	14000	<8.0	144	<0.20	7270	0.30	18.2	52.2	31.8	47300	0.090	1500	6560
$\bar{x}$	<0.080	13700	<8.0	163	<0.20	8100	<0.30	23.0	69.1	28.6	81100	0.085	1400	6230
S.D.	--	1040	--	20.6	--	815	--	10.5	36.5	2.9	66700	0.02	173	352
V*	--	8.3	--	13.7	--	10.9	--	49.3	57.3	10.9	89.1	29.6	13.4	6.1
4-1	0.10	15500	<8.0	169	<0.20	7280	<0.30	10.4	32.1	56.3	26900	0.073	1900	6390
4-2	<0.080	13600	<8.0	140	<0.20	7570	<0.30	14.0	39.2	40.8	43400	0.084	1700	5740
4-3	<0.080	15400	<8.0	176	<0.20	8130	0.50	16.1	36.9	44.5	33900	0.114	1800	6210
$\bar{x}$	<0.080	14800	<8.0	162	<0.20	7660	<0.40	13.5	36.1	47.2	34700	0.090	1800	6110
S.D.	--	1070	--	19.1	--	432	--	2.9	3.6	8.1	8280	0.02	100	336
V*	--	7.8	--	12.8	--	6.1	--	23.1	10.9	18.6	25.8	25.4	6.0	5.9

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 4 BIG CRLEK SEDIMENT ANALYSIS - METALS - JULY 24, 1984 (Continued)
(all concentrations given in mg/L unless otherwise noted)

STATION	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg
5-1	<0.080	14200	<8.0	156	<0.20	8290	<0.30	15.7	42.8	42.0	46800	0.109	1600	5890
5-2	<0.080	13500	<8.0	163	<0.20	7440	<0.30	15.0	38.1	35.4	39400	0.083	1500	5560
5-3	<0.080	15100	<8.0	150	<0.20	6880	<0.30	13.9	33.3	46.1	29300	0.088	1850	6340
$\bar{X}$	<0.080	14200	<8.0	156	<0.20	7540	<0.30	14.9	38.1	41.2	38500	0.093	1650	5930
S.D.	--	900	--	6.5	--	710	--	0.9	4.8	5.4	8780	0.01	180	392
V*	--	6.9	--	4.5	--	10.2	--	6.6	13.5	14.2	24.7	16.0	11.8	7.2
6-1	<0.080	16000	<8.0	180	<0.20	7780	<0.30	13.4	33.3	52.4	28900	0.100	2100	6450
6-2	<0.080	13300	<8.0	153	<0.20	8070	<0.30	14.1	39.8	35.2	41200	0.070	1400	5400
6-3	<0.080	13600	<8.0	185	<0.20	8260	<0.30	14.1	36.9	34.3	35500	0.394	1500	5520
$\bar{X}$	<0.080	14300	<8.0	173	<0.20	8040	<0.30	13.9	36.7	40.6	35200	0.188	1670	5790
S.D.	--	1479	--	17.2	--	242	--	0.4	3.3	10.2	6160	0.2	379	575
V*	--	11.2	--	10.8	--	3.3	--	3.2	9.6	27.2	18.9	103	24.6	10.8
Stoddart														
St. -1	<0.080	14000	<8.0	212	<0.20	9720	<0.30	18.2	43.7	17.9	63300	0.064	1300	5510
-2	<0.080	14200	<8.0	182	<0.20	9230	<0.30	16.0	37.0	20.7	49000	0.102	1300	5480
-3	<0.080	17000	<8.0	248	<0.20	8920	0.50	10.5	30.4	25.9	26100	0.111	1600	6130
$\bar{X}$	<0.080	15000	<8.0	214	<0.20	9290	<0.40	14.9	37.0	21.5	46100	0.092	1400	5730
S.D.	--	1680	--	33.0	--	403	--	4.0	6.7	4.1	18800	0.03	173	402
V*	--	12.1	--	16.7	--	4.7	--	28.8	19.5	20.5	44.1	29.3	13.4	7.6

$\bar{X}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 4 BIG CREEK SEDIMENT ANALYSIS - METALS - JULY 24, 1984 (Continued)
(all concentrations given in mg/L unless otherwise noted)

STATION	Mn	Mo	Na	Ni	P	Pb	Si	Sn	Sr	Ti	V	Zn
1-1	634	<0.080	740	25.0	2010	11.0	1170	3.0	85.9	1740	146	94.7
1-2	557	<0.080	730	30.0	1990	10.0	1100	2.0	90.2	1890	140	99.3
1-3	542	<0.080	810	32.0	1940	16.0	660	2.0	93.4	1750	119	98.4
$\bar{x}$	578	<0.080	760	29.0	1980	12.3	977	2.3	89.8	1790	135	97.5
S.D.	49.4	--	43.6	3.6	36.1	3.2	276	0.6	3.8	83.9	14.2	2.4
V*	9.3	--	6.2	13.5	2.0	28.2	30.7	26.8	4.5	5.1	11.4	2.7
2-1	540	<0.080	740	24.0	2070	11.0	880	4.0	90.0	2260	194	106
2-2	521	<0.080	700	22.0	2080	15.0	900	7.0	87.0	1960	157	99.1
2-3	492	<0.080	710	23.0	1890	10.0	860	4.0	84.4	1670	120	93.6
$\bar{x}$	518	<0.080	717	23.0	2010	12.0	880	5.0	87.1	1960	157	99.6
S.D.	24.2	--	20.8	1.0	107	2.6	20.0	1.7	2.8	295	37.0	6.2
V*	5.1	--	3.1	4.7	5.8	23.9	2.5	37.5	3.5	16.3	25.5	6.8
3-1	426	<0.080	650	18.0	1770	8.0	910	<2.0	71.1	1830	130	80.2
3-2	667	<0.080	540	12.0	2660	35.0	190	<2.0	63.2	3940	593	162
3-3	481	<0.080	590	20.0	1610	12.0	760	<2.0	65.5	1630	160	92.4
$\bar{x}$	525	<0.080	593	16.7	2010	18.3	620	<2.0	66.6	2470	294	112
S.D.	126	--	55.1	4.2	566	14.6	380	---	4.1	1280	259	44.1
V*	26.1	--	10.1	27.1	30.4	86.1	66.4	---	6.6	56.2	95.4	42.9
4-1	350	<0.080	580	16.0	1310	9.0	1550	<2.0	67.6	1150	77.0	70.6
4-2	375	<0.080	560	14.0	1670	6.0	650	3.0	64.4	1810	148	78.7
4-3	366	<0.080	620	17.0	1610	<6.0	970	3.0	70.8	1630	110	74.8
$\bar{x}$	364	<0.080	587	15.7	1530	---	1060	<3.0	67.6	1530	112	74.7
S.D.	12.7	--	30.6	1.5	193	---	456	---	3.2	341	35.5	4.1
V*	3.8	--	5.6	10.6	13.7	---	46.8	---	5.1	24.2	34.5	5.9

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 4 BIG CREEK SEDIMENT ANALYSIS - METALS - JULY 24, 1984 (Continued)
(all concentrations given in mg/L unless otherwise noted)

STATION	Mn	Mo	Na	Ni	P	Pb	Si	Sn	Sr	Ti	V	Zn
5-1	403	<0.080	600	15.0	1800	10.0	600	5.0	67.0	2020	162	84.2
5-2	367	<0.080	570	15.0	1570	7.0	720	3.0	61.9	1680	134	73.4
5-3	338	<0.080	540	16.0	1250	5.0	1300	2.0	63.9	1180	87.0	72.4
$\bar{x}$	369	<0.080	570	15.3	1530	7.3	873	3.3	64.3	1630	128	76.7
S.D.	32.6	--	30.0	0.6	287	2.5	374	1.5	2.6	422	37.9	6.5
V*	9.6	--	5.7	4.1	20.3	37.2	46.4	49.6	4.3	28.1	32.2	9.2
6-1	375	<0.080	620	16.0	1400	7.0	1280	3.0	72.0	1280	86.0	73.2
6-2	377	<0.080	530	13.0	1810	7.0	1140	3.0	62.9	1870	142	74.2
6-3	355	<0.080	730	13.0	1820	7.0	970	5.0	64.7	1720	119	69.2
$\bar{x}$	369	<0.080	627	14.0	1680	7.0	1130	3.7	66.5	1620	116	72.2
S.D.	12.2	--	100	1.7	240	0.0	155	1.2	4.8	307	28.1	2.6
V*	3.6	--	17.3	13.4	15.5	0.0	14.9	34.1	7.8	20.5	26.4	4.0
Stoddart												
St. -1	496	<0.080	930	8.0	2450	16.0	920	7.0	78.4	2950	217	111
-2	468	<0.080	870	10.0	2080	20.0	1180	3.0	78.9	2130	164	104
-3	416	<0.080	910	14.0	1500	5.0	1000	4.0	95.6	1160	75.0	87.3
$\bar{x}$	460	<0.080	903	10.7	1940	13.7	1030	4.7	84.3	2080	152	101
S.D.	40.6	--	30.6	3.1	579	7.1	133	2.1	9.8	896	71.8	12.2
V*	9.6	--	3.7	31.0	32.6	61.6	14.0	48.3	12.6	46.7	51.1	13.1

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX TABLE BIG CREEK SEDIMENT ANALYSIS - METALS - AUGUST 14, 1984 (Continued)
(all concentrations given in mg/L unless otherwise noted)

STATION	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg
1-1	--	19900	<8.0	177	<0.20	10800	0.70	14.2	70.9	31.7	31700	0.079	1440	10300
1-2	--	14800	<8.0	212	<0.20	7590	0.60	8.4	19.1	28.7	24200	0.075	1310	4850
1-3	--	16100	<8.0	125	<0.20	8400	0.50	16.6	57.9	20.3	31200	0.054	1180	8530
$\bar{x}$	--	16900	<8.0	171	<0.20	8930	0.60	13.1	49.3	26.9	29000	0.069	1310	7890
S.D.	--	2650	---	43.8	--	1670	0.10	4.2	26.9	5.9	4190	0.01	130	2780
V*	--	17.0	---	27.7	--	20.3	18.1	35.0	59.2	23.8	15.6	21.0	10.8	38.2
2-1	--	17400	<8.0	184	<0.20	8830	0.70	14.4	49.9	24.6	29200	0.075	1430	8180
2-2	--	12800	<8.0	96	<0.20	8070	0.50	12.0	44.3	13.9	32100	0.038	1110	6490
2-3	--	16300	<8.0	147	<0.20	7610	0.40	12.1	45.0	21.2	26100	0.060	1280	7790
$\bar{x}$	--	15500	<8.0	143	<0.20	8170	0.50	12.8	46.4	19.9	29100	0.058	1270	7490
S.D.	--	2400	---	43.8	--	616	0.20	1.4	3.1	5.5	3000	0.02	160	885
V*	--	16.8	---	33.3	--	8.2	31.0	11.5	7.1	29.8	11.2	35.0	13.6	12.8
3-1	--	12200	<8.0	124	<0.20	6810	<0.30	13.0	37.1	43.3	37200	0.067	1290	5860
3-2	--	14100	11.0	162	<0.20	7290	0.40	15.4	43.7	48.6	42100	0.060	1470	6350
3-3	--	14200	<8.0	159	<0.20	7670	<0.30	13.8	44.1	34.2	39900	0.051	1350	6190
$\bar{x}$	--	13500	<9.0	148	<0.20	7260	<0.30	14.1	41.6	42.0	39700	0.059	1370	6130
S.D.	--	1130	---	21.1	--	431	--	1.2	3.9	7.3	2454	0.028	91	250
V*	--	9.0	---	15.4	--	6.4	--	9.4	10.2	18.8	6.7	14.6	7.2	4.4
4-1	--	10400	<8.0	184	<0.20	6780	<0.30	15.6	36.6	48.8	44300	0.048	1290	4490
4-2	--	17500	10.0	233	<0.20	8370	<0.30	18.1	37.4	118.0	39800	0.088	2200	7160
4-3	--	15700	<8.0	190	<0.20	8130	<0.30	14.5	35.4	65.4	29700	0.039	1848	6200
$\bar{x}$	--	14500	<8.6	202	<0.20	7660	<0.30	16.1	36.5	77.4	37900	0.058	1780	5950
S.D.	--	3690	---	26.7	--	857	--	1.8	1.0	36.1	7480	0.03	457	1350
V*	--	27.5	---	14.3	--	12.0	--	12.4	3.0	50.6	21.4	48.4	27.8	24.6

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 4 BIG CREEK SEDIMENT ANALYSIS - METALS - AUGUST 14, 1984 (Continued)
(all concentrations given in mg/L unless otherwise noted)

STATION	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg
5-1	--	15000	<8.0	136	<0.20	8050	<0.30	16.9	42.3	52.7	44800	0.085	1740	6090
5-2	--	12500	<8.0	180	<0.20	7230	<0.30	12.9	36.8	36.7	38100	0.093	1290	5210
5-3	--	10900	<8.0	167	<0.20	5930	<0.30	8.5	27.0	35.6	28300	0.042	1230	4730
$\bar{x}$	--	12800	<8.0	161	0.00	7070	<0.30	12.8	35.4	41.7	37100	0.073	1420	5340
S.D.	--	2060	--	22.6	--	1070	--	4.2	7.8	9.6	8300	0.03	278	690
V*	--	17.5	--	15.2	--	16.4	--	35.7	23.7	24.9	24.3	40.5	21.2	14.0
6-1	--	12700	<8.0	180	<0.20	7380	<0.30	13.7	36.9	39.0	36900	0.039	1420	5320
6-2	--	14400	<8.0	187	<0.20	8030	0.30	14.6	33.7	52.2	32000	0.048	1630	5800
6-3	--	16000	13.0	205	<0.20	7500	<0.30	13.9	30.7	66.3	26500	0.057	2020	6520
$\bar{x}$	--	14370	<9.6	191	<0.20	7640	<0.30	14.1	33.8	52.5	31800	0.048	1690	5880
S.D.	--	1650	--	12.9	--	346	--	0.5	3.1	13.7	5200	0.009	304	604
V*	--	12.4	--	7.3	--	4.9	--	3.6	9.9	28.2	17.7	20.3	19.5	11.1
Stoddart	--													
Cr. -1	--	14400	<8.0	217	<0.20	8410	0.40	12.5	27.3	21.2	27900	0.069	1290	5000
-2	--	14900	<8.0	211	<0.20	8750	0.40	13.3	30.7	23.3	34600	0.057	1290	5340
-3	--	12100	<8.0	167	<0.20	7700	0.50	11.1	26.4	18.4	31200	0.042	997	4560
$\bar{x}$	--	13800	<8.0	198	<0.20	8290	0.40	12.3	28.1	21.0	31200	0.056	1190	4970
S.D.	--	1490	--	27.3	--	536	0.10	1.1	2.3	2.5	3350	0.01	169	391
V*	--	11.7	--	14.9	--	7.0	14.4	9.8	8.7	12.7	11.6	26.2	15.4	8.5

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 4 BIG CREEK SEDIMENT ANALYSIS - METALS - AUGUST 14, 1984 (Continued)
(all concentrations given in mg/L unless otherwise noted)

STATION	Mn	Mo	Na	Ni	P	Pb	Si	Sn	Sr	Ti	V	Zn
1-1	761	<0.080	720	42.0	1570	19.0	140	4.0	112	1120	97.9	109
1-2	375	<0.080	420	8.0	1240	18.0	660	<2.0	77.6	700	68.8	128
1-3	515	<0.080	610	32.0	1400	20.0	500	3.0	80.4	1180	99.7	94.8
$\bar{x}$	550	<0.080	583	27.3	1340	19.0	433	<3.0	90.0	1000	88.8	111
S.D.	195	--	152	17.5	85.0	1.0	266	--	19.1	262	17.3	16.7
V*	38.5	--	28.2	69.3	6.9	5.7	66.6	--	23.0	28.3	21.2	16.3
2-1	605	<0.080	620	30.0	1310	17.0	190	5.0	89.8	1000	89.9	105
2-2	438	<0.080	550	21.0	1640	13.0	<20	<2.0	66.2	1050	109	82.3
2-3	492	<0.080	530	28.0	1130	15.0	320	5.0	77.8	869	76.5	96.4
$\bar{x}$	512	<0.080	567	26.3	1360	15.0	<143	<4.0	77.9	973	91.8	94.6
S.D.	85.2	--	47.3	4.7	259	2.0	--	--	11.8	93.5	16.3	11.5
V*	18.0	--	9.0	19.4	20.6	14.4	--	--	16.4	10.4	19.3	13.1
3-1	448	<0.080	780	17.0	1360	15.0	470	3.0	55.4	1200	119	85.6
3-2	468	<0.080	490	19.0	1320	17.0	300	4.0	62.7	1390	134	94.7
3-3	457	<0.080	510	18.0	1390	17.0	390	4.0	64.9	1460	135	88.6
$\bar{x}$	451	<0.080	593	18.0	1360	16.3	387	3.7	61.0	1350	129	89.6
S.D.	15.7	--	162	1.0	35.1	1.2	85.0	0.6	5.0	135	9.0	4.6
V*	3.8	--	29.6	6.0	2.8	7.7	23.8	17.1	8.8	10.8	7.5	5.6
4-1	347	<0.080	380	12.0	1420	15.0	360	5.0	47.8	1460	156	70.0
4-2	561	<0.080	490	18.0	1110	16.0	80.0	4.0	74.4	1310	119	86.0
4-3	329	<0.080	540	15.0	1230	13.0	110	2.0	66.5	1190	89.5	69.2
$\bar{x}$	412	<0.080	470	15.0	1250	14.7	183	3.7	62.9	1320	122	75.1
S.D.	129	--	81.9	3.0	156	1.5	154	1.5	13.7	135	33.3	9.5
V*	33.9	--	18.9	21.7	13.5	11.3	90.8	45.1	23.5	11.1	29.7	13.7

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 4 BIG CREEK SEDIMENT ANALYSIS - METALS - AUGUST 14, 1984 (Continued)
(all concentrations given in mg/L unless otherwise noted)

STATION	Mn	Mo	Na	Ni	P	Pb	Si	Sn	Sr	Ti	V	Zn
5-1	448	<0.080	490	15.0	1320	19.0	150	5.0	68.1	1520	151	83.7
5-2	361	<0.080	430	12.0	1280	13.0	250	2.0	56.7	1320	130	70.7
5-3	319	<0.080	390	12.0	1070	10.0	450	4.0	47.5	947	91.1	60.6
$\bar{x}$	376	<0.080	437	13.0	1220	14.0	283	3.7	57.4	1260	124	71.7
S.D.	65.8	--	50.3	1.7	134	4.6	153	1.5	10.3	291	30.4	11.6
V*	19.0	--	12.5	14.4	11.9	35.5	58.4	45.1	19.5	25.0	26.5	17.5
6-1	363	<0.080	440	14.0	1310	14.0	250	4.0	57.4	1320	124	70.9
6-2	423	<0.080	470	15.0	1260	13.0	200	2.0	65.8	1170	100	73.0
6-3	449	<0.080	490	18.0	954	13.0	350	3.0	69.9	935	71.4	73.8
$\bar{x}$	412	<0.080	467	15.7	1180	13.3	267	3.0	64.4	1140	98.5	72.6
S.D.	44.1	--	25.2	2.1	193	0.6	76.4	1.0	6.4	194	26.3	1.5
V*	11.6	--	5.8	14.4	17.8	4.7	31.0	36.1	10.7	18.4	29.0	2.2
Stoddart												
Cr. -1	397	<0.080	470	10.0	1170	13.0	890	5.0	78.5	1250	89.7	76.7
-2	458	<0.080	430	11.0	1350	19.0	700	5.0	79.4	1340	111	94.9
-3	396	<0.080	350	8.0	1510	17.0	630	4.0	59.2	1320	104	82.9
$\bar{x}$	417	<0.080	417	9.7	1340	16.3	740	4.7	72.4	1300	102	84.8
S.D.	35.5	--	61.1	1.5	170	3.1	134	0.6	11.4	47.3	10.9	9.3
V*	9.2	--	15.9	17.1	13.7	20.3	19.7	13.4	17.1	3.9	11.6	11.8

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 4 BIG CREEK SEDIMENT ANALYSIS - METALS - SEPTEMBER 18, 1984 (Continued)
(all concentrations given in mg/L unless otherwise noted)

STATION	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg
1-1	0.090	14500	<8.0	115	<0.20	8170	0.8	14.7	62.6	26.8	33900	0.179	1410	7230
1-2	<0.080	10900	<8.0	86.5	<0.20	6440	1.1	12.5	49.8	13.1	29400	0.053	1080	5980
1-3	<0.080	15300	<8.0	124	<0.20	8580	0.9	17.8	67.2	35.2	37100	0.062	1250	7990
$\bar{x}$	<0.080	13500	<8.0	109	<0.20	7730	0.9	15.0	59.9	25.0	33500	0.098	1250	7070
S.D.	--	2310	--	19.6	--	1140	0.2	2.7	9.0	11.2	3870	0.07	165	1010
V*	--	18.5	--	19.5	--	15.9	17.7	19.2	16.3	48.3	12.5	77.7	14.3	15.6
2-1	<0.080	9610	<8.0	109	<0.20	7060	0.8	16.9	55.1	15.3	56900	0.043	906	5070
2-2	0.080	11200	<8.0	152	<0.20	7840	0.8	19.5	83.2	31.6	55900	0.069	1130	6020
2-3	<0.080	8980	<8.0	113	<0.20	7400	0.8	21.8	70.6	19.2	77300	0.060	1020	4800
$\bar{x}$	<0.080	9930	<8.0	125	<0.20	7430	0.8	19.4	69.6	22.0	63400	0.057	1018	5300
S.D.	--	1140	--	23.8	--	391	.0	2.5	14.1	8.5	12100	0.01	112	641
V*	--	12.5	--	20.6	--	5.7	.0	13.7	21.9	41.8	20.6	24.9	11.9	13.1
3-1	0.130	10600	<8.0	133	<0.20	6600	0.7	14.8	53.5	36.6	49700	0.072	1270	4840
3-2	<0.080	9970	<8.0	121	<0.20	6330	0.8	13.4	57.9	30.5	36500	0.069	1170	4850
3-3	<0.080	10300	<8.0	129	<0.20	6400	1.0	18.6	105	37.5	50100	0.059	1310	5350
$\bar{x}$	<0.090	10300	<8.0	128	<0.20	6440	0.8	15.6	72.1	34.9	45400	0.067	1250	5010
S.D.	--	315	--	6.1	--	140	0.2	2.7	28.5	3.8	7740	0.007	72.1	292
V*	--	3.3	--	5.2	--	2.4	19.9	18.7	42.9	11.8	18.5	11.1	6.2	6.3
4-1	<0.080	9270	<8.0	128	<0.20	6240	0.8	15.8	48.7	39.9	58700	0.067	1270	3990
4-2	0.220	11300	<8.0	166	<0.20	6060	0.6	10.1	26.7	44.2	25600	0.046	1510	4710
4-3	<0.080	10300	<8.0	152	<0.20	6990	0.9	18.5	44.8	33.9	53400	0.053	1270	4380
$\bar{x}$	<0.130	10300	<8.0	149	<0.20	6430	0.8	14.8	40.1	39.3	45900	0.055	1350	4360
S.D.	--	1020	--	19.2	--	493	0.2	4.3	11.7	5.2	17800	0.01	139	360
V*	--	10.7	--	14.0	--	8.3	21.6	31.4	31.7	14.2	42.0	20.9	11.1	9.0

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 4 BIG CREEK SEDIMENT ANALYSIS - METALS - SEPTEMBER 18, 1984 (Continued)
(all concentrations given in mg/L unless otherwise noted)

STATION	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg
5-1	<0.080	9300	<8.0	180	<0.20	5310	1.2	8.6	27.2	37.7	24600	0.069	1480	3880
5-2	<0.080	9630	<8.0	172	<0.20	5870	0.8	13.2	37.2	33.0	36800	0.083	1380	4020
5-3	0.090	12600	<8.0	180	<0.20	6700	0.7	12.4	34.3	39.3	25900	0.075	1660	5200
$\bar{x}$	<0.080	10510	<8.0	177	<0.20	5980	0.9	11.4	32.9	36.7	29100	0.076	1500	4370
S.D.	--	1820	---	4.6	--	731	0.3	2.5	5.1	3.3	6700	0.007	139	725
V*	--	18.7	---	2.8	--	13.2	31.8	23.4	16.9	9.7	24.9	10.1	10.0	18.0
6-1	0.080	10300	<8.0	144	<0.20	6320	1.9	12.2	35.3	29.2	37200	0.041	1430	4790
6-2	<0.080	11300	<8.0	161	<0.20	7060	0.9	10.4	39.7	31.9	34500	0.061	1420	4880
6-3	<0.080	10600	<8.0	130	<0.20	5820	0.9	11.0	31.6	30.8	24400	0.066	1600	4500
$\bar{x}$	<0.080	10700	<8.0	145	<0.20	6400	1.2	11.2	35.5	30.6	32000	0.056	1480	4720
S.D.	--	513	---	15.5	--	624	0.6	0.9	4.1	1.4	6750	0.01	101	199
V*	--	5.2	---	11.6	--	10.6	50.7	8.9	12.4	4.8	22.8	25.6	7.4	4.6
Stoddart														
Cr. -1	<0.080	11600	<8.0	170	<0.20	8120	0.9	3.2	29.2	15.7	30700	0.057	1280	4370
-2	0.100	11300	<8.0	158	<0.20	7860	1.0	6.7	28.4	19.8	29700	0.645	1190	4310
-3	<0.080	9380	<8.0	135	<0.20	6540	0.9	12.6	24.8	13.9	25300	0.070	1150	3660
$\bar{x}$	<0.090	10800	<8.0	154	<0.20	7510	0.9	7.5	27.5	16.5	28600	0.257	1210	4110
S.D.	--	1204	---	17.8	--	847	0.1	4.8	2.3	3.0	2870	0.336	66.6	394
V*	--	12.1	---	12.5	--	12.2	6.7	68.6	9.2	19.9	10.9	141	6.0	10.4

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 4 BIG CREEK SEDIMENT ANALYSIS - METALS - SEPTEMBER 18, 1984 (Continued)
(all concentrations given in mg/L unless otherwise noted)

STATION	Mn	Mo	Na	Ni	P	Pb	Si	Sn	Sr	Ti	V	Zn
1-1	475	<0.080	720	33.0	1470	19.0	980	5.0	77.0	1250	132	86.7
1-2	363	<0.080	590	26.0	1260	15.0	1300	3.0	59.1	1060	119	71.2
1-3	517	<0.080	1310	35.0	1640	18.0	1000	7.0	82.5	1410	149	90.6
$\bar{x}$	452	<0.080	873	31.3	1460	17.3	1030	5.0	72.9	1240	133	82.8
S.D.	79.6	--	384	4.7	190	2.1	179	2.0	12.2	175	15.0	10.3
V*	19.1	--	47.6	16.3	14.2	13.0	17.8	43.3	19.2	15.3	12.2	15.4
2-1	407	<0.080	550	19.0	1740	18.0	1380	10.0	58.4	2130	255	86.9
2-2	486	<0.080	630	43.0	1680	48.0	1250	33.0	67.1	1900	240	96.9
2-3	458	<0.080	470	24.0	1840	27.0	660	18.0	57.6	2810	344	98.2
$\bar{x}$	450	<0.080	550	28.7	1750	31.0	1100	20.3	61.0	2280	280	94.0
S.D.	40.1	--	80.0	12.7	80.8	15.4	384	11.7	5.3	473	56.2	6.2
V*	9.6	--	15.8	47.9	5.0	55.8	37.9	62.2	9.4	22.5	21.8	7.1
3-1	421	<0.080	520	24.0	1410	17.0	460	10.0	54.5	1820	210	86.9
3-2	381	<0.080	690	32.0	1400	24.0	1470	16.0	52.5	1370	151	72.4
3-3	519	<0.080	550	71.0	1400	75.0	1240	52.0	55.4	1480	204	88.7
$\bar{x}$	440	<0.080	587	42.3	1400	38.7	1060	26.0	54.1	1560	188	82.7
S.D.	71.0	--	90.7	25.1	5.8	31.7	529	22.7	1.5	235	32.5	8.9
V*	17.5	--	16.8	64.3	0.4	88.7	54.3	94.6	3.0	16.3	18.7	11.7
4-1	348	<0.080	420	14.0	1440	17.0	1060	9.0	43.6	2070	254	72.5
4-2	273	<0.080	420	11.0	1090	10.0	1900	4.0	48.5	1070	94.3	54.3
4-3	356	<0.080	450	11.0	1580	16.0	1350	9.0	50.0	2100	252	73.0
$\bar{x}$	326	<0.080	430	12.0	1370	14.3	1440	7.3	47.4	1750	193	66.6
S.D.	45.8	--	17.3	1.7	252	3.8	427	2.9	5.3	586	86.6	10.7
V*	15.2	--	4.4	15.6	20.0	28.6	32.2	42.6	7.7	36.4	48.5	17.3

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance

APPENDIX VI TABLE 4 BIG CREEK SEDIMENT ANALYSIS - METALS - SEPTEMBER 18, 1984 (Continued)
(all concentrations given in mg/L unless otherwise noted)

STATION	Mn	Mo	Na	Ni	P	Pb	Si	Sn	Sr	Ti	V	Zn
5-1	290	<0.080	370	15.0	955	12.0	1770	7.0	42.2	871	91.9	53.9
5-2	381	<0.080	400	18.0	1170	18.0	1370	7.0	47.5	1250	152	69.5
5-3	387	<0.080	460	19.0	1110	11.0	1270	4.0	61.0	987	93.4	64.5
$\bar{x}$	353	<0.080	410	17.3	1080	13.7	1470	6.0	50.2	1040	112	62.6
S.D.	54.4	--	45.8	2.1	110	3.8	265	1.7	9.7	194	34.3	8.0
V*	16.7	--	12.1	13.0	11.1	30.0	19.5	31.3	20.9	20.3	33.0	13.8
6-1	349	<0.080	2500	16.0	1410	14.0	1890	3.0	50.9	1490	156	65.1
6-2	354	<0.080	830	17.0	1480	15.0	1390	6.0	54.9	1480	141	71.4
6-3	336	<0.080	490	16.0	1030	11.0	1450	4.0	50.0	934	90.2	56.4
$\bar{x}$	346	<0.080	1270	16.3	1310	13.3	1580	4.3	51.9	1300	129	64.3
S.D.	9.3	--	1080	0.6	242	2.1	273	1.5	2.6	318	34.5	7.5
V*	2.9	--	91.5	5.8	20.1	16.9	18.8	38.2	5.4	26.5	28.9	12.7
Stoddart												
Cr. -1	381	<0.080	380	10.0	1630	14.0	1320	6.0	65.1	1500	122	78.8
-2	405	<0.080	480	12.0	1530	17.0	1420	6.0	68.1	1340	117	94.9
-3	383	<0.080	360	11.0	1370	15.0	1120	4.0	52.5	1120	99.3	67.6
$\bar{x}$	390	<0.080	407	11.0	1510	15.3	1290	5.3	61.9	1320	113	80.4
S.D.	13.3	--	64.3	1.0	151	1.5	153	1.2	8.3	191	11.9	13.7
V*	3.7	--	17.1	9.8	9.4	10.8	12.9	23.5	14.5	15.7	11.5	18.5

$\bar{x}$ - Arithmetic Mean
S.D. - Standard Deviation
V* - Variance